THE ENGINEERING MAGAZINE

AN INDUSTRIAL REVIEW

VOLUME XXXIV

October, 1907, to March, 1908

NEW YORK

THE ENGINEERING MAGAZINE

1908

392

COPYRIGHT, 1907

BY JOHN R. DUNLAP

THE ENGINEERING MAGAZINE

THE WORLD IS ITS FIELD

VOL. XXXIV. OCTOBER, 1907. No. 1

THE COPPER SITUATION IN THE UNITED STATES.

A STUDY OF THE STATISTICAL POSITION AND ECONOMIC OUTLOOK.

By James Douglas.

COPPER has of late occupied in the public eye a larger field of view than perhaps its importance as a national industry warrants. This has been due to the abnormal price to which it has rapidly risen—a price which has been in a certain sense fictitious, as probably none of the producing companies ever realized this price on much of their product. The producing companies, though not interested in the manufacturing companies, very properly contract ahead to supply the manufacturing companies with the raw material they have to deliver as a manufactured article. There is, so far, a community of interest between the two branches of the industry. The producing companies, therefore, have been selling ahead on a steadily rising market, and have consequently not realized by a very substantial figure the current prices published weekly. But, nevertheless, the price has been sufficiently remunerative to excite in the public mind such a feverish desire to own copper stocks that these have run up to a high figure. There is no reason to assign any other explanation for the high price than the perfectly legitimate one that the demand was for the time being in excess of the supply, that stocks have been exhausted, and the metal was therefore scarce. Imagining that the scarcity would continue, and would be perennial, the price continued to soar until the demand fell off, and the delusion was dissipated.

There has been for the last ten years an average rate of 84 tons of iron consumed to 1 ton of copper, as per the following tables of production and consumption of the two metals:

Year.	Pig-Iron Production in United States.	Per Cent of Increase.	Pig-Iron Consumption in United States.	Per Cent of Increase.
1897	9,652,680	11.94	9,381,914	13.36
8	11,773,934	20.97	12,005,674	27.96
9	13,620,703	15.67	13,779,442	14.69
1900	13,789,242	1.23	13,177,409	*4.45
1	15,878,354	15.29	16,232,446	23.18
2	17,821,307	12.23	18,436,870	13.58
3	18,009,252	*1.61	18,039,909	*2.15
4	16,497,003	8.39	16,679,555	*7.54
5	23,010,625	39.48	23,155,624	38.82
6	25,307,191	9.98	26,603,202	14.88
	Total 165,360,291	Average 12.00	Total 167,492,045	Average 13.23

The world's demand for the two metals was in the same ratio, and the world's production of copper also shows a notable percentage decrease. The production was in 1897,—405,350 tons, and in 1906, 718,368 tons, or an average increase for ten years of 4.3 per cent, whereas between the production of 1905, which was 699,504 tons, and that of 1906, there was a gain of only 15,754 tons, or 2.03 per cent. —hence the rise in price. That iron did not sympathize in price is due to the fact that the undeveloped resources of iron ore, and the metallurgical appliances for its reduction to metal, are much greater than those of copper. Consequently iron can bear a temporary strain better than copper.

Moreover, the standard price for iron has been fixed at a figure high enough to compensate for wide variations in the market. The average price of the two metals for ten years has been as follows:

Year.	Southern Pig Iron.	Lake Copper.
1897	10.25 per ton	11.29 per lb.
1898	10.45 " "	12.03 " "
1899	17.75 " "	17.61 " "
1900	18.35 " "	16.52 " "
1901	14.60 " "	16.55 " "
1902	20.10 " "	11.89 " "
1903	18.31 " "	13.42 " "
1904	13.92 " "	12.99 " "
1905	16.66 " "	15.70 " "
1906	19.44 " "	19.62 " "

* Decrease.

† We have accepted the statistics as published in the *Mineral Industry*. They do not include copper from the lead desilverizers, which, until 1901 was considerable; but on the other hand they include copper sulphate which the Government statistics omit. The consumption, which is of course largely a matter of speculation and doubt, as the stock on hand can never be determined with accuracy, is only calculated in the Government report since 1901.

Pig-Copper Production in United States.	Per Cent of Increase.	Pig-Copper Consumption in United States.	Per Cent of Increase.	Tons Pig Iron Consumed to 1 Ton Pig Copper.
221,958	6.32	122,500	20.	77
236,109	6.38	122,383	* .10	98
255,272	8.12	174,822	42.85	79
263,178	3.09	155,169	*11.24	85
266,716	1.34	196,837	26.85	82
284,284	6.59	209,241	6.30	88
316,239	11.24	221,222	5.73	82
365,051	15.43	208,082	* 5.94	80
390,733	7.04	273,652	31.51	85
409,652	4.84	298,472	9.07	89
Total 3,009,192	Average 7.39	Total 1,982,379	Average 12.50	Average 84

Between the price of rails early in 1897 of $16.00 per ton, and the present price of $28.00 per ton, there is, however, as wide a difference as between the price of copper in 1896, $10.88, and the price of copper in 1906, $19.62. But there can be a policy pursued in regulating the home prices of iron which cannot be followed in the case of copper. Iron is protected; copper is not; and, therefore, if desired by the large manufacturers of iron to maintain a staple price, the very large margin of $11.20 per ton of steel and of $4.00 per ton of pig iron, which the duty gives them, may be used. In case of a low foreign price, a high domestic price can be sustained; or in case of high foreign price, the domestic price may be maintained at a given standard up to the limit of the duty. The McKinley Bill struck off all duty on crude and refined copper, though retaining it on manufactured copper. Thus, the world's price regulates the American domestic price, and the copper producers have been saved from any temptation to form a copper trust, in order to derive the benefit of the duty. As to the regulation of price, considering our supreme position as producers it may be more proper to say that we fix the price of the world. For a short period this year, the English price ruled slightly lower than the price demanded in the United States, and copper immediately commenced to flow in from abroad, although over any considerable period of time, say the past ten years, 54.5 per cent of our production has been exported and we make 54.7 per cent of the world's total.

In spite of the active demand and the high price, last year's domestic production showed, as per the above table, that there were only two years, since copper became a prominent article of domestic production, when copper production showed as slight a percentage of gain.

A steadily progressive high percentage increase, however, cannot be maintained and should not be expected when the gross increase reaches certain limits. For instance, in 1896, when the percentage of increase over 1895 was 21 per cent, the actual increase was 81,168,640 pounds; but during the last decade, the production has increased at such a rate that the 4.8 per cent increase of 1906 over 1905 represents an actual increase of 42,378,560 pounds of copper—an increase of 137.4 per cent over the production of 1895, or of 451.1 per cent over that of 1885.

Still, it is significant that this notable falling off in percentage increase should occur when the high price of copper may be supposed to have served as a stimulus to the utmost activity. The world's increase, as well as our own, showed a diminished percentage of increase—being 2.16 per cent instead of 6.16 per cent of the previous years. To explain this anomaly, it must be borne in mind that as the average of the percent of the ore treated was probable lower, more ore in proportion to the output of copper was probably mined. When copper is 20 cents, money can be made out of ore which is valueless with copper standing at 12 cents; and, therefore, should the contents of the mines permit of selection, ore is utilized at one time which at another time is rejected. Moreover, the average percentage of ore of the great mines of the country is declining, and will continue to decline. Rich bodies of secondary deposits may be discovered in any deep mine, which may arrest the decline in its average yield, but the world's experience is not likely to be reversed in our favor—more especially as it coincides with our own—that the average yield of deep copper mines declines with depth; and as with declining yield generally occurs the increased cost of mining incident to greater depth, two factors concur to bring about the reduced production, which must occur sooner or later.

In comparing iron and copper mining, and the ease with which the varying demands of trade may be met by the producers, it must be remembered that 2 tons of average iron ore from the most prolific source now available—Lake Superior—will make 1 ton of metal; whereas from 33 to 75 tons (say an average of 50 tons) of copper ore must be mined to produce 1 ton of copper. A sudden increase in demand for the baser metal can be more readily met than when such a call is made for the rarer. The relative supply in nature may be gauged by the value on which the price of each is made, the value of iron being generally quoted by the ton, and of copper by the pound. Last year's production of iron was made from approximately 50,000,-

000 tons of ore. Our copper mines, to yield a production of 900,000,000 pounds, must have handled approximately 22,000,000 tons of ore, or nearly half the quantity of ore raised from our iron mines. The ore of iron moreover occurs in very large deposits, worked in some cases by steam shovels, whereas our copper comes from comparatively narrow veins or irregular masses.

Referring to the relative growth and decline of the three principal sources of the metal since the Western States began to grow into prominence, say from 1882, we find that at that date the Lakes supplied from ores of metallic copper 25,000 long tons of copper; Arizona, from oxidized ores, 8,000 long tons of copper; and Montana, from sulphide ores, 4,000 long tons. After that, the Lake production relatively declined. The Montana production continued to increase rapidly until 1887, when Montana took the first place with 35,000 tons, Lake Superior second place with 34,000, and Arizona third, with 8,000. This order was maintained until 1905, when Arizona attained the second rank.

Meanwhile, however, notable contributions were made from neglected States which had again become active producers, or from entirely new territory. Before the Civil War broke out, Tennessee was the largest producer on the Appalachian Range. The active mines shipped during the first nine months of 1855, 14,291 tons of ore of 25 per cent—the Hiawassee alone shipping 4,156 tons. Smelting works were successfully started that year, and before the war broke out, the copper produced was being refined on the spot. After the war mining declined and for a time production ceased. But when the mines were reopened new metallurgical methods were very skilfully applied, and in 1896 Tennessee made 3,750,124 pounds of copper; but last year the State is credited with 18,821,000 pounds. Utah until recently has made an almost negligible quantity, but last year she added to the nation's stock 49,712,000 pounds. California in the sixties and seventies occupied a prominent position, but her production sank to 120,156 pounds in 1894. The revival commenced with the opening of the Mountain Copper Mine in 1896 and with a product of 1,120,000 pounds, which sprung to 14,000,000 in the following year. It now stands at 24,421,000 pounds. What Alaska will do, the future only will show. The large lenses of cupriferous pyrites on the coast in Hetta inlet sent into the market last year 8,700,000 pounds of copper, most of it treated at the Tacoma works. The largest sources of new supply, which can be counted on with tolerable certainty, will be found in the low-grade ores of Utah and Nevada, where works on a very large scale are being planned or erected for their treatment.

It is expected that within two or three years 15,000 to 20,000 tons of ore a day, containing not only copper but carrying notable quantities of the precious metals, will be concentrated and smelted in these two States, which should add to our total about 200,000,000 pounds a year.

The presence of small quantities of gold and silver in copper ores, now that the process of electrolytic copper refining permits these elements to be cheaply separated among the impurities, is putting within the range of profitable extraction ores of very low percentage in copper. When the Anaconda mine was first opened, and its rich ores (and subsequently the mattes, made from them) were shipped to Europe for refining, the margin of gold and silver deducted from the ton of copper, before any allowance was made to the shipper, was $60.00. As this deduction was substantially the whole of the precious metals in the Butte copper, the company derived no benefit. Whatever margin there was in the $60 over and above the heavy cost of separation went to the refiners. Most of the rich argentiferous copper was then converted into bluestone. But since electrolysis has been applied to copper refining, and the process has been carried out on a large scale, the commercial charges for refining the copper and separating the precious metals have been reduced from $60 to $16, and as the value of the electrolytically refined copper is ordinarily about $10 a ton above that of furnace-refined copper, copper bars containing $6 in precious metals can be economically converted into electrolytic, and their gold and silver added to the world's wealth. If the copper bars contain the concentrated gold and silver of 30 tons of ore, the ore need contain only 20 cents of gold and silver per ton to make it profitable to submit the resulting copper to electrolysis. The amount thus extracted from domestic and foreign ores in the refineries of the United States is approximately:—from Montana, $6,650,000; Arizona and Sonora, $2,105,000; Canada, $460,000; and other sources $2,500,000—or over $11,000,000—most of which formerly entered the refined copper and was wasted.

While the presence of precious metals in high-grade ores redounds to the fortunate copper company which mines them, when ores of 2 per cent and under (like those of the Boundary District of British Columbia, or Bingham Cañon in Utah, or of Ely County in Nevada) are treated, the addition of $2 or $3 in gold and silver per ton may convert an unprofitable into a very profitable mineral. And from such ores will probably come much of the copper from our new mineral developments; for it is not probable that within the explored territory, many new large deposits will be discovered which are also

of high grade, whereas lean ores in very large quantities are known to exist in many districts of the country. Apart from their contents in precious metals, better machinery and improved metallurgical methods permit of ores being treated economically today, which would not have been classed as ore a few years ago; and today ores are rejected in developed mines, which at no distant day may help us to maintain our position in the copper world.

But as already pointed out, we cannot expect to grow as vigorously as we did in the past. We are using up our natural resources of iron, copper, and lumber at headlong speed, and they cannot last. Nevertheless, there need be no immediate alarm as to a heavy decline in our copper supply. While even such large reserves as the Calumet and Hecla once had in the conglomerate beds are within measureable distance of exhaustion, others of the company's mines on the Osceola and Kearsarge amygdaloid promise to enable it to maintain its output, and the success of the Wolverine and Mohawk to the northeast of Portage Lake, and of the Baltic and other mines on the Copper Range to the southwest, are prophetic of what will gradually happen as the vast area of the amygdaloid and conglomerate beds which circle round from the Keweenaw promontory through Wisconsin into Minnesota are explored. They are so buried under forests and soil that their development will be slow, but the possibilities hidden within them are incalculable. Montana, which heretofore has meant Butte, has held her own simply by increasing her concentrating and smelting facilities to compensate for the gradual decline in her ores; but the discovery of large copper bodies at great depth below the argentiferous ores of the North Butte mine and of others within what was considered formerly as the silver zone, and also to the south and east of what was once supposed to be the limit of the copper zone, may extend the life of Butte indefinitely beyond the limits assigned to it even by its most enthusiastic supporters; and Butte will not be the only copper district of Montana, though probably none as productive will ever be discovered.

Arizona, which has made more rapid strides of late than its competitors, owes its progress mainly to the remarkable mining developments in the limestones of the Warren district in the neighborhood of Bisbee; and as yet, the limit of these large deposits, either laterally or in depth, has not been determined. In the Clifton district, the very large quantities of low-grade ores which support the Arizona Copper Company, the Detroit Copper Company, and the Shannon and other minor companies, show no signs of exhaustion. Other deposits of the

same general character and of great magnitude, in Mineral Creek and elsewhere in Arizona, and in the Burro Mountains in New Mexico, assure us of a sure supply, if not a very rapid increase for some time to come from the Southwestern States. This assurance is confirmed by the rapid growth of the mines in the neighborhood of Globe, and from the production of the large number of small mines in the southwest, many of which are producing, and all of which are appealing to the public for support. The experience of the past year warns us, however, that the period of rapid expansion has passed, and that as the home demand will probably not fall off, we shall have less of our own copper for export than formerly. But this deficiency will probably be supplied from foreign ore or metallurgical products treated in our furnaces and refineries. Last year's statistics show an importation of foreign copper, partly in ores, partly in matte, and partly in unrefined bars, of 136,826,906 pounds. Most of this was from Mexico, some from Canada, some even from New Zealand. It is to the credit of our smelters and refineries that so large a quantity of copper should seek our shores for final treatment, some coming even from a British colony at the antipodes. This is due as much to their business methods as to the excellency and economy of their metallurgical work. The scale on which they work is liberal, and that is one reason why their scale of charges is attractive.

The *Mineral Industry* for 1906 gives the amount of electrolytic copper turned out by nine electrolytic refineries at 865,000,000 pounds, and their capacity, at 1,120,000,000 pounds. Distributing the actual amount refined proportionately among the refineries, if the capacity of each is correctly given, the production of each is as follows:

APPROXIMATE ANNUAL CAPACITY AND PRODUCTION OF ELECTROLYTIC COPPER, FOR YEAR ENDING DEC. 31, 1907.

		Capacity, lb.	Calculated production based on proportionate distribution of assumed total electrolytic copper output.
Nichols Copper Co.....	Laurel Hill, N. Y..	288,000,000	222,516,000
Raritan Works	Perth Amboy, N. J.	288,000,000	222,516,000
American Sm. & Refg. Co...	Perth Amboy, N. J.	144,000,000	111,168,000
U. S. Metals Refg. Co.....	Chrome, N. J.....	144,000,000	111,168,000
Baltimore	Baltimore, Md.	130,000,000	100,360,000
Balbach Sm. & Refg. Co....	Newark, N. J.....	75,000,000	57,900,000
Boston & Montana Cop. Co..	Great Falls, Mont..	30,000,000	23,160,000
Tacoma Smelting Co.....	Tacoma, Wash. ...	18,000,000	13,896,000
Mountain Copper Co.....	Oakland, Cal.	3,000,000	2,316,000
		1,120,000,000	865,000,000

The very large quantity of copper carried in the vats of these electrolytic works introduces an element of uncertainty into the calculation of stocks on hand, and of consumption. It also influences the price, as the value of copper is undoubtedly influenced by the quantity in stock, actually available for sale and yet unsold. This is a matter of some moment at a period when production is on the increase. It must be remembered that any increase in production at the mines and at the mines' smelting works, does not enter the market for at least 90 days—as 30 days must be allowed for western copper in transit and 60 days for its electrolytic and furnace treatment at the refineries. If, therefore, there has been an increase in production at all the mines of the country of, say, 5,000,000 pounds, in any given month, this 5,000,000 becomes 15,000,000, before it reaches the market as salable copper. Moreover this addition to the copper in the vats of the electrolytic refineries, as long as the refineries continue to run up to a given capacity, should be no more counted as marketable stock than if it were still copper unmined and in the ground. At the present time there must be under treatment in the vats about 100,000,000 pounds of copper. In case of a great scarcity and a rise in price which would tempt the owners of this reserve stock to sacrifice its gold-silver contents, it would be speedily available. A reserve of this kind is a safeguard, not a menace to the market. Outside of this item it is very difficult to determine at any time what is in stock. In England a certain amount of copper is held under warrant and can be, and is, counted on as stock; but this is delusively small. In the United States the stock on hand is subject to guess work. That at the present moment it is increasing cannot be questioned; but it is small compared with the volume of business the metal has to support and the fluctuating needs of trade.

To forecast the future of copper is impossible. It is safe to predict that, if no substitute is discovered and the demand for the metal increases as it has done during the modern industrial era, the supply will fall short of the demand and the value of the metal will rise. The same is true of all the mineral products that are consumed in the arts. The experience of the last few years in the United States illustrates, however, the sensitive connection between demand and price. The table at the top of the following page shows that sudden excess of demand is generally followed by augmentation of price, because production does not as quickly respond.

AVERAGE PRICE OF LAKE COPPER IN NEW YORK.

Year.	Price.	Per Cent Increase in Production.	Per Cent Increase in Consumption.
1896	10.88	....	.....
1897	11.29	6.32	10.
1898	12.03	6.38	42.85
1899	17.61	8.12	11.24
1900	16.52	3.09	26.85
1901	16.55	1.34	6.30
1902	11.88	6.50	5.73
1903	13.41	11.24	5.94
1904	12.99	15.43	31.51
1905	15.69	7.04	9.07

While such spasmodic variations are transitory, there can be no doubt that if the demand grows and no very important new discoveries are made, the metal will become scarcer and will command a higher price than the average price of the past. One consequence, which will also be a corrective, will be that the metal will cease to be used for purposes to which it is turned today, and for which a cheaper material can be discovered. For it is an invariable rule that when the metal has run up above a figure which deters purchasers from using it except for unavoidable purposes, the consumption drops off sharply, and a more normal value is restored.

WORLD'S PRODUCTION BY QUINQUENNIAL PERIODS FROM 1881-1905.

	1881-1885. Tons.	1886-1890. Tons.	1891-1895. Tons.	1896-1900. Tons.	1901-1905. Tons.
United Kingdom	16,082	5,200	2,665	3,000	2,542
Spain and Portugal..	215,306	267,592	273,497	263,800	244,996
Germany	74,064	79,551	83,350	104,165	107,735
Austria	2,775	5,061	6,200	5,175	5,535
Hungary	3,240	2,355	1,290	2,165	1,460
Sweden	3,962	3,985	2,790	2,495	2,300
Norway	13,126	7,987	9,092	17,110	25,575
Russia	20,248	23,445	24,980	31,335	46,395
Italy	6,640	8,562	12,300	15,765	15,755
Turkey	.....	.....	.....	2,885	5,130
Chili	202,145	145,785	107,205	120,950	149,915
Venezuela	19,252	22,316	14,950	.....	.....
Japan	36,300	66,097	91,480	125,325	159,370
China	Unknown.	Unknown.	Unknown.	Unknown.	Unknown.
United States	261,649	468,998	760,004	1,179,932	1,643,810
Australasia	56,283	45,987	40,500	89,770	159,235
Argentine	1,792	840	950	565	770
Africa:—					
Algeria	2,310	590	155	50	.....
Cape	25,608	34,915	31,520	35,160	31,180
Newfoundland	5,717	8,705	10,170	10,300	10,540
Bolivia	10,594	6,950	12,060	10,850	10,000
Peru	2,041	800	1,920	18,165	40,280
Canada	4,791	10,815	21,000	33,175	95,325
Mexico	1,889	13,771	44,385	82,340	227,660
	985,814	1,230,307	1,552,463	2,154,477	2,985,508

The all-important factors in discussing the future are the questions of sources of supply and the uses to which the metal is turned. The table on the opposite page is extracted from Brown and Turnbull's Century of Copper, and illustrates the decay and actual extinction of certain copper regions, and the growth of others. But the most vigorous of today will sooner or later be in the declining list.

The most notable features of the table are the virtual disappearance of Great Britain and Venezuela. Venezuela depended, however, upon only one great mine—the New Quebreda. In Great Britain, it has been a case of slow decline. The reduction in Spanish and Portuguese production is much more important. It is due to the approaching exhaustion of the large pyrites bodies worked by the Tharsis Co. and Mason & Barry, and points to the time, still happily distant, when even the vast resources of the Rio Tinto Company will have been worked out. To their huge lenses of sulphate of iron the chemical trade of the world looks for a cheap supply of the material for making sulphuric acid, and no similar source in such quantity or so advantageously situated exists elsewhere. The German production comes from one mine, the famous old Mansfeld. It has been worked since the thirteenth century, and has still comparatively a long life ahead. Turning to the American continent, we have already discussed the possibilities of our own future. Chili suffered a terrible decline after the exhaustion of her rich ores from her three great mining districts between 1870 and 1880, but she is now imitating us, and beginning to recognize the value of her leaner ores, and learning to utilize them. She, Bolivia, and Peru will show an increase in the future. So also will Mexico; and British Columbia will make progress with moderate speed. But upon the American continent, both South and North, there are wonderful possibilities of future discovery—in Alaska, and in British Columbia; in the Labrador peninsula; in the great belt of country in which cobalt and native silver deposits have so recently been discovered between the Lakes and Hudson Bay. Nor should the great Canadian Northwest even within the Arctic Circle be eliminated from view, for even Hearne's Copper River would not be shut off by ice from the world's markets by the closure of Hudson Bay for many more months than were the mines of Lake Superior till within very recent years, when their copper production could reach the east only after the opening of navigation.

The African Continent, as the table shows, has maintained a very stationary production. But in Africa there is in view the only large

copper region said to be within reach of a future market. The Tanganyika Concessions, Ltd., claims to have discovered and sufficiently explored deposits of great extent in the Congo Free State, and the adjacent North-West Rhodesia, to make it probable (they consider certain) that this region will become one of the world's greatest sources of supply. But the deposits lie in the very heart of the continent, on the 12th degree of south latitude, and a thousand miles of railroad must be built before supplies and copper can be transported in and out between the West Coast and the mines.

Australia, the table shows, has made some progress, and will probably continue to move forward. So far as Russia in Asia has been explored, no mines of great promise have been exposed, but very little is really known of the possibilities of either Siberia or China.

Japan appears as a growing copper power, but this year her production will probably show no increase, owing to the labor riots and destruction of property at some of her copper mines. While she has undeveloped and partially developed resources which will increase her output, she has also created for herself in Corea, Manchuria, and Formosa, fields for industrial expansion which may absorb all her excess.

A review, therefore, of the world's mines would seem to indicate that the old mines are approaching exhaustion, that no new large deposits of rich ore, except possibly those of Tanganyika, are in sight; and therefore the trade must turn to deposits of lower grade than have heretofore been worked, if the demand continues as active as at present. And copper cannot be made as cheaply from mines of that class as from the mines we have been drawing upon so recklessly for a generation.

The next question bearing upon values is that of probable consumption. The three principal uses to which copper is now turned are:—in the manufacture of electrical machinery and the transmission of electrical current; in the composition of alloys, principally brass, for stationary engines, locomotives, railroad cars, automobiles, and for arms and ammunition, and in architecture, where it replaces iron and lead.

The Government has issued an advance sheet, giving its figures of production, importation, and exportation for 1906. The production differs from that of the *Mineral Industry* by 11,000,000 pounds, and makes the increase over 1905 only 2.03 per cent instead of 4.08 per cent. The statement makes the total of copper actually produced from domestic and foreign ores 1,097,961,969 pounds, and the exports

446,750,711, leaving a balance of 651,211,258 pounds. The Boston News Bureau assigns the following consumption to the five principal consumers in the United States:

American Brass Co.	250,000,000	
Roebling & Sons Co.	100,000,000	
General Electric Co.	75,000,000	
American Steel & Wire Co.	50,000,000	
National Conduit Co.	50,000,000	
		525,000,000

This leaves for all other consumers and for margin of error, 126,211,358 pounds, which is probably not far from the mark.

Glancing at the three sources of consumption, the draft on copper for telegraph wires, trolley lines, long-distance transmission and other electrical purposes, is of comparatively recent date, and is doubtless very large—probably about one-third of the world's supply goes into this new industry; but comparatively little of it is actually consumed, though a great deal of it is through carelessness wasted during the installation of plants. The copper remains in service with little waste, or goes back to the refineries as scrap. But the demand for this purpose will not fall off. The urban and interurban mileage of trolley lines in the United States is between 30,000 and 40,000 miles. They have been built within very recent years, and new lines are reticulating the country. No substitute for copper in this class of roads has been suggested, for though aluminum may indifferently replace copper for current transmission, it cannot bear the wear and tear of the trolley. Gradually, also, the motor will displace the locomotive on all our present steam roads where traffic is dense; and though the third rail instead of the trolley wire will be used, the amount of copper which goes into the transmission, the generators, the motors, and all subsidiary appliances, will increase the proportionate demand for the metal by electricians.

The amount of copper which enters brass and other alloys it is difficult to determine. From information derived from several of our large railroad systems I would infer that about 5 grains of copper are consumed and actually go out of existence per car mile. This would represent about 5,000 tons of copper consumed by our railroads per annum for this purpose alone. Automobiles must make a new and very heavy call on copper, and the demand for stationary engines and steamboats is increasing with the growing industrial activity of the country. The quantity used up in war material and ammunition—during peace and war—is very great. In spite of probable fluctuations in the brass trade, there will be a large and satisfactory average growth.

But when we come to the third principal use for copper, that is, in the building and house-furnishing trade, we find it playing the part of an article of luxury. Our forefathers were satisfied with wrought-iron railings in their city houses, beautiful examples of which still exist in all the west-side streets of the old residential portion of New York City. Now we must have bronze balustrades in our palatial offices, hotels and private buildings. Brass or bronze hinges and locks, gas fixtures, etc., appear in profusion in our houses and railroad cars, and brass and copper have driven out lead for roofing and plumbing. When copper is abundant and sells at a moderate price, it is the most desirable material for these purposes, but as it becomes rarer and dearer, substitutes for it will be used. As long, however, as money is forthcoming, the public taste for brass and bronze will be gratified, and probably more of the world's supply will go into architecture and house-furnishing than into any other use.

From the above review of the sources of supply and the sources of demand, it would seem that while there is no risk of copper becoming a rare metal in the near future, it will certainly have to be extracted from much leaner ores at an increased cost. Also while there is no reason to believe that its consumption in the arts will grow less, there are metals which can be substituted for it, should the popular taste or financial exigencies require.

PROSPERITY; ITS RELATION TO THE INCREASING PRODUCTION OF GOLD.

By Alex. Del Mar.

Mr. Del Mar was formerly Director of the United States Bureau of Commerce, Navigation and Statistics; official delegate to the International Statistical Congresses held in Florence, The Hague, and St. Petersburgh; a member of various governmental Monetary Commissions; and he is an authority of international reputation on the use of the precious metals as money. Three years ago, in answer to a private inquiry by the editors of this Magazine, he outlined the certain consequences of the vast additions which were and still are being made to the world's store of gold, and predicted with most striking accuracy the phenomena that have since appeared and are now apparent in economic and industrial affairs. Responding to our invitation to follow the analysis further, Mr. Del Mar has extended the range of his observation over a wider field, with results even more keenly interesting in view of the present state of the business and financial mind. His article will be read with close attention and with profit, by those who demur as well as those who fully assent to his reasoning.—THE EDITORS.

WHEN a period of commercial prosperity becomes prolonged, it begins to invite the caution of the prudent and arouse the fears of the timid. Such an interval occurred during the Civil War and such another one is passing at the present time. It is at periods of this character that every circumstance which tends to heighten the prevailing distrust is brought forward by interest, prejudice or passion, and displayed as the true cause of the commotion. The prosecution of certain railways for secret rebating; the condemnation of certain monopolies for repeated violations of law and good faith; these and other pretexts are being sedulously put forward as the causes of the existing financial uneasiness. Nor are such grounds of alarm entirely destitute of plausibility; for alarm feeds as readily upon belief as fact; upon sentiment, as upon reason. But after a careful examination of the subject, it will be found that, aside from a remediable constriction in the monetary field, there is nothing in the situation to warrant any apprehension for the immediate future; and as for such constriction, it is not pressing.

The circumstances which denote prosperity or adversity in the United States embrace the outlook of Peace or War; Legislation; the Crops; Mines; Forests and Fisheries; Immigration; Manufactures; Foreign and Domestic Commerce; Railroads; Real Estate; Labor; Interest; Prices; and Money. Of these in their turn.

The United States is at peace with all the world and itself; and appears likely so to remain. When it is considered that this country has never experienced a panic that could not be traced to its own legislative blunders, the importance of mature legislation by jurists thoroughly acquainted with economic laws can not be overestimated. The new conditions of this century demand the repeal of much of our lawyers' law and the enactment in its place of a little scientific law. These preliminaries bring us at once to the consideration of our principal source of prosperity—the agricultural crops.

THE CROPS of 1907 can happily be rapidly summarized. The report of the Agricultural Department for August indicates a crop of maize (corn), of about 2,650 million bushels; wheat, winter, 410, spring, 230, total 640 million bushels; together with crops of oats, barley, rye, buckwheat, tobacco, potatoes and hay equal to the average harvest of recent years. The cotton crop is still a matter of speculation. Of last year's crop there were "brought into sight," down to the first week in August, no less than 13,383,661 bales, against 11,052,063 bales at the same time the preceding year. The outlook for 1907 is for over 12 million bales, and the European demand so keen that the Texas planters are clamoring for a union to hold for 15 cents a pound, the prevailing price being about 13½ cents for mid-upland.

When these colossal crop figures are multiplied by the enhanced prices which these staples now command, it will be found that the farmers and planters are likely to receive as much money for this year's produce as they got for last year's, and perhaps more. This means about six billion dollars.

The early fruit harvests have yielded, and the later ones, such as apples and grapes, promise, the usual abundance. From Maine to California and from the Lake region to the Gulf, Nature has poured forth such a profusion of agricultural wealth that nothing short of a *cadastre* can do justice to the subject. In almost every respect and in all important respects, it is a year of plenty.

The statistical returns from the mines, forests, and fisheries are not yet completed. Indications point to an increased product of gold, silver, copper, iron and coal, and a normal product of the other commodities included under these heads. The latest returns of the mineral product are those for the calendar year 1906, which Mr. Ingalls summarizes in his *Mineral Industry* as follows: The production of some two-score ores and minerals aggregated 819 millions, besides 177 millions of secondary minerals and chemicals. Metals yielded 873 millions, the gross total being 1,869 millions of dollars in value. The mines of the Transvaal yielded in July 54,438 fine ounces of gold,

against 54,918 in June and 48,485 in July last year. The monthly average output this year amounts to nearly 50,000 ounces, much more than doubling the average of 1904, and making an increase of nearly 3,000 ounces per month over last year. The output of the last three months has been the greatest ever recorded.

Thus, in the production of the year 1907, there is to be observed no material falling off, in any general direction; and in most directions, a material gain. In a few words, the original material elements of prosperity produced this year should bring to the producers as much money as they did last year or more. The foundations of our welfare are thus seen to be solid; but what of the superstructure?

Immigration, whatever its intellectual or moral influences, has always been regarded as a source of wealth to the country, the immigrant bringing with him his money, goods, and knowledge. This year's immigration is the greatest in the history of the United States. The total number of immigrants in 1906 was 1,100,735, whilst in 1907 it was 1,285,349. As the immigrant brings with him on the average something over $100 in money and goods, we derive from this source alone an accession of material wealth to the country amounting to about 150 millions of dollars per annum.

The cry of the Far West for labor, which continues to fall as much short of demands as at any time last year, is one of the signs that prosperity remains at high pressure in that section of the country. The railroads, which were forced last Fall to advertise all over the East for men, offering inducements in transportation and wages, are still suffering; and not only are present extension projects in the West being held up for shortage of labor, but the fuel-supply problem for next winter is complicated by the same cause. In Utah mine labor is so scarce that Japanese are drawing as high as $170 a month.

DOMESTIC MANUFACTURES AND TRADE. With the object of ascertaining the true condition and prospects of manufactures and trade an enquiry was addressed in August to the leading trade papers in each principal line of industry, those best qualified to furnish reliable replies. The general result was summarized in these words:

> "With scarcely an exception each line of industrial activity shows an encouraging degree of progress, and in no case is there a forecast of the future colored by pessimistic forebodings. It is pointed out, as the one negative feature in the situation, that there is a scarcity of money in the markets; but this very lack of money is quoted as an evidence of business activity. Thus, on all sides America's business future is deemed to be built on a solid basis and there is no room given by these experts in trade-conditions to the belief that the threat of coming hard times is visible on the country's horizon."

The language in which the assurance is couched might have been improved; but the assurance itself was both ample and satisfactory.

Dun's Commercial Review reported that the industry and trade of the commercial world had outstripped its supply of monetary facilities. Wall Street had suffered from the fall in railway shares, yet the earnings of the roads were greater than ever. The mills and factories throughout this country have been kept busy and have found a ready sale for finished products at profitable prices.

The R. H. Macy department store stated that business this year had shown no curtailment and the prospects for the Fall trade were most encouraging.

The *Implement Age* reported an unusually heavy demand for agricultural implements. In all lines the demand has exceeded the supply. Manufacturers have but one difficulty—that of filling orders. Manufactories are being enlarged, more plants erected, and additional workmen employed. Europe cannot compete with America in this trade, and we are exporting 27 millions a year in harvesters, plows, cultivators, etc. The hardware-trade journals all report increased activity in manufactures and trade, largely due to the immense crops of agricultural produce and to the enhanced ability of the rural classes to buy. In machinery and builders' hardware the reports are to the same effect. Prospects for the Fall trade were never so good.

The *Motor,* a journal of the automobile trade, reported that the prospects of the trade were of the highest character and that after the market for pleasure carriages was supplied, the trade would find its extension in the power-wagon for trade purposes—a vehicle which was steadily supplanting the horse-drawn wagon.

The *Bicycling World* said that 1906 was a better year than 1905, and 1907 better than 1906. The trade had recovered from the craze of past years, and is now on a healthy basis. It doubted if there was more than one manufacturer in the trade whose books would not show both increase of production and profit.

The *American Pottery Gazette* reported depleted stocks in the hands of traders; an active demand in all branches of the china, glass and pottery trades; and well-filled order books of the manufacturers; the general outlook being "roseate."

The *American Silk Journal* said that the unusual depression in the first half of 1906, due to short crops of raw silk, had been overcome and that there is every prospect of a large business in the coming season. This year's crop reports from Japan, China, and Italy being favorable, additional mills are starting up in New England, New Jersey and Pennsylvania, for weaving ribbons and broad silk; and new

throwing and dyeing plants in New York, New Jersey, and Pennsylvania. Nearly all the weaving mills have increased their capacity. Selling agents complain of not being able to obtain sufficient goods to fill their orders. Buyers in July and August have already placed enough orders to ensure a big business for the Fall.

The *House-Furnishing Review* reports that manufacturers have found it difficult to catch up with orders; many new retail concerns established; the construction of additional manufacturing plants is under way; and the prospect is of a lively Fall trade. The favorable condition of the agricultural crops has afforded an additional stimulus to an already busy trade. Prices are firm and markets steady; very little accumulation of stock in any line; and general condition of trade highly satisfactory.

The *Upholsterer* reports that the vast number of new dwellings being constructed throughout the country has occasioned an unusual demand for upholstery and house decorations. There are more American homes being built today than ever before. There is hardly a dry-goods store that has not found it necessary to put in furniture and drapery departments. Owing to the backwardness of the Spring weather, this Fall promises an enormous trade. Many buyers, anticipating difficulty in filling orders, have gone to complete their purchases in Europe. No indications of lower prices. The importers have never been busier. American furniture manufactories are being driven to their fullest capacity. All the mills are employing more hands and making provision to increase their trade.

The *Real-Estate Record,* a purely local journal, reports that, so far as New York City is concerned, the number of new buildings is slowly declining from previous high records—an indication that the local supply has in some measure caught up with the demand. The number of new buildings this year since January 1 is about 14,000, against 22,000 same time last year. The high price of land, the increased number of very large apartment-houses, and the removal of many families to the suburbs and to Western and Southern cities and villages, will probably account for this situation. The building news from the suburbs and from the countless towns and villages along the principal lines of railways and trolley routes, shows increased building operations, and the result is reflected in the increasing demand for lumber, builders' hardware, furniture, upholstery, and building and furnishing materials generally. Leaving New York city out of view, the condition of the house-building trade was never more prosperous than it is at present, and the prospects for Fall construction were never greater.

The *Wall Paper News* reports the construction of additional plants, larger buildings, and other evidences of an expected increase of trade in wall papers. The absence of Spring weather had occasioned a falling off, which it was believed would be more than made good during the coming Fall.

The *Lead and Zinc News* reports this year's production of lead in the Missouri-Kansas district to have been greater by 5,517 tons than for the corresponding period last year. Prices of lead have declined; while those of zinc have advanced, under large European orders. The mail-order houses continue to sell enormous quantities of prepared paint for house painting, an indication of increased means on the part of the rural population, the principal buyers.

The *Oil, Paint and Drug Reporter* says that business is exceptionally good in all lines, and 15 to 25 per cent greater than in 1906. The demand for drugs and pharmaceutical preparations is steady; chemical products are contracted for several years ahead. Petroleum and linseed oils continue in steady demand. Cotton-seed oil demand, falling off. The general outlook is optimistic.

The *Boot and Shoe Recorder* reports requests for early deliveries of Fall orders, indicating reduced stocks and large expected demand. The prices of raw leather have risen faster than those of manufactured goods; but it is believed that the latter will soon follow suit. An unusual number of buyers in the Boston market indicates a growing demand, and everything points to a large Fall trade.

The *International Studio,* a journal of the trade in works of art, reports that the present is a period of unprecedented prosperity in all lines of the art trade.

The *Jewellers' Weekly* reports that the condition of the jewelry trade is eminently satisfactory, and that the prospects for the Fall trade are unusually bright. All lines have been steadily progressing. The prosperity of the jeweller has been practically uninterrupted. Over 41-million dollars' worth of diamonds had been imported during the year, at the port of New York alone. All departments of the trade showed increased activity, and in low-grade gold and plated jewelry, the demand far exceeded the supply. It is not the perturbations of the stock market, but the amplitude of the agricultural crops, that determines the prosperity of the principal lines of trade in jewelry.

Broomhall's July estimate of the wheat crop of the world is 2,992 million bushels, against 3,281 million bushels in 1906, Europe exhibiting a shortage of 173 million bushels. This condition of the world's principal breadstuffs bespeaks an active demand for American wheat.

and continued prosperity for American millers, railways and shippers. And from the *Carpet and Upholstery Trade Review,* from *Men's Wear* and the *Apparel Gazette,* from *Fabrics, Fancy Goods and Notions,* from the *American Hatter,* from *Playthings,* from the *Publisher and Retailer,* representing the book trade, and from the *Daily Trade Record* representing men's wearing apparel, comes the same story; demand overtaxing the supply, outlook for Fall trade excellent, traders short of desirable goods.

RAILROADS. The statements by a number of roads showing their gross earnings for the month of July, 1907, exhibit the striking feature practically without exception of large increases of earnings over those for the corresponding month of last year. One scans in vain the railroad statements which have recently come to hand for any indication of a let-up in general business. The gross earnings for July during the last eight years, commencing with 1900, were respectively, 46, 46, 57, 62, 56, 47, 71, and 81 millions.

IRON AND STEEL. The *Iron Age* reports continued and increasing activity in the iron and steel markets. The August production of pig iron is expected to exceed that of July. The United States Steel Corporation, to fill its orders, has been obliged to purchase, since April 1, no less than 86,500 tons of billets from outside companies; its own immense capacity being inadequate to cope with demand.

COPPER. The production of the Calumet, Lake Superior, Butte, and British Columbia districts for July equalled 130 million pounds, valued at about 28 million dollars.*

In short, the reports of our domestic manufactures and trade exhibit an increase in all directions; provisions, metals, machinery, hardware, building materials, agricultural implements, carriages, dry goods (draperies), lumber, wooden-wares, skins and leather, oils, paper, publications, chemicals, drugs, dyes and medicines, soaps, spirits, tobacco, and a host of minor articles. Increased millions of men and machines are employed in their preparation and fabrication, and increased railways and ships in their transportation and distribution.

Our commerce, both foreign and domestic is greater than ever.

FOREIGN. The imports during the fiscal year 1905 were 1,118 millions; 1906, 1,227 millions; and 1907, 1,434 millions; the domestic exports were in 1905, 1,492; 1906, 1,718; and 1907, 1,855 millions; showing an immense gain this year over recent and indeed all previous years. The re-exports of foreign goods were about the same, 26 millions, in each of the years mentioned; so that they call for no

* The copper situation is discussed at length and with authority by Dr. Douglas, in the article immediately preceding this.

special remark. The foreign commerce of 1907 alone affords us an apparent balance of trade amounting to not less than 447 million dollars. The imports of gold in 1906 were 92 millions; in 1907, 115 millions. The exports of gold in 1906 were 39 millions; in 1907, 51 mililons. Among the imports the most noticeable gains over 1906 were in the articles listed in the table just below; the sums attached showing the value in millions of dollars. As many of the articles imported, notably dry-goods, iron and steel wares, sugar, silk, spirits, wines, ales, tobacco, and woolens, had to pay a high rate of duty, it is evident that the rise in the cost of materials, rents, and wages in the United States enables the foreign articles, plus duty, to enter American markets at a price below their domestic rivals, when there is one; a fact of the highest importance in considering the workings of a tariff.

The principal articles of domestic exports in 1907, all but four of which show a gain over the previous year, are summarized on the right-hand side of the table; values being given in millions of dollars:

PRINCIPAL IMPORTS AND EXPORTS DURING THE FISCAL YEAR ENDING JUNE 30, 1907.

IMPORTS.	MILLIONS OF DOLLARS.	EXPORTS.	MILLIONS OF DOLLARS.
Chemicals, Drugs and Dyes	83	Agricultural Implements	27
Cocoa	14	Cattle, Horses and Live Animals	41
Coffee	78	Cereals, Grains and Flour	184
Copper	48	Carriages and all other Vehicles	21
Cotton Goods	74	Chemicals, Drugs and Dyes	20
Diamonds and Precious Stones	43	Coal and Coke, excluding Bunker Coal for Foreign Trade	38
Flax, Hemp and Jute	42	Copper and Manufactures of	95
Manfs. of Hemp and Jute Flax	67	Cotton, Raw	482
Fruits and Nuts	36	Cotton, Manufactures of	32
Furs and Manufactures of	30	Flax and other Seeds	10
Gums	15	Fruits and Nuts	18
Hides and Skins	83	Instruments (Scientific)	14
India Rubber	63	Iron and Steel, Machinery and Hardware	182
Iron and Steel and Manfs. of	41	Leather and Manufactures of	45
Leather and Manufactures of	20	Lumber	70
Oils	17	Meats and Dairy Products	202
Paper	11	Naval Stores	22
Raw silk	71	Oil Cake and Meal	26
Manufactures of Raw Silk	39	Mineral Oils	85
Spirits, Wines and Malt Liquors	22	Paper and Manufactures of	10
Sugars	93	Paraffine and Wax	9
Tin	38	Tobacco and Manufactures of	39
Tobacco and Manufactures of	30	Vegetable Oils	20
Woods and Manufactures of	43	Wood, Manufactures of	14
Wool	42		
Manufactures of Wool	23		
Total	1166	Total	1706

INTEREST. It is only when we enter the obscure domain of finance that the industrial problem becomes puzzling; but even this

clears up before the lime-lights of those economical principles, the working of which, but ill understood, is the cause of the prevailing uncertainty in the commercial mind. One of these is the Rise in the Rate of Interest; a second is the Rise of Prices; and a third is the Supply of Money.

As any given rate of interest must consist of three elements, namely, profits in trade, the cost of the superintendence of loans, and insurance against loss, the first being variable and of the greatest importance, the others being usually constant and (in the United States) of less importance, it is easy to deduce that any general rise of profits will cause a rise in the rate of interest. As a matter of fact, the recent rise in the rate was foreseen and publicly predicted several years ago.

One of the inevitable consequences of a rise in interest is a fall in bonds, or in the value of anything yielding merely a fixed income. Hence the fall in New York municipal bonds and in numerous other securities with a fixed income, a fall which has puzzled our younger financiers and driven them into pessimism and alarm. So far is a high rate of interest, when accompanied by a normal cost of superintendance and insurance, removed from a bad symptom, that it is in fact the best of all symptoms; it is a certain evidence of high profits in production and trade. There is little risk in predicting that before many years the tide will turn the other way, when the now despised municipal bonds will rise to 130 or thereabouts.

PRICES. We now approach a subject which brings us close to the crux of the present situation—the Rise of Prices; for it is under this head that stocks, commodities, real-estate and labor are engaged in that struggle, which the unsophisticated view with doubt and distrust.

Two years ago and in the July number of this MAGAZINE, it was shown that the gold dredgers and other recently invented gold-producing and gold-saving devices were turning out nearly a million of dollars a day of gold; and it was predicted that "within the next ten years this output would increase to two millions a day." The world's product has already passed the million mark; and is steadily approaching the two-million mark.

Under the impulse of this great increase of the precious metal from which money is coined, and of the bank-note issues based upon it, and of the cheque, clearing-house, telegraphic, and telephone systems and other agencies and arrangements which have been established to expedite the velocity and efficiency of money, there has occurred a rise of prices, which everybody perceives, but nobody has yet resolved into order. From very careful observations which have been

made in the United States, it appears that following a given increase of money, and taking no account of the time involved in geographically distributing the increase, it nevertheless requires a period of some years for all prices to conform to such increase. During this time, the prices of a certain few classes of commodities or services will double; after which the prices of others will double; and so on successively, until the doubling of all classes is completed. In other words, the doubling of prices will not be simultaneous, but will take the form of a precession, the order of which will be somewhat as follows:

I, Stocks, or shares of incorporated companies. II, Staples, or crude and imperishable commodities. III, Merchandise, such as perishable commodities, crude articles of subsistence, etc. IV, Fabrics, such as machinery, manufactured food, dry-goods, etc. V, Landed property, or real estate. VI, Skilled labor, or artisans' wages. VII, Unskilled labor, or the wages of laborers, etc. VIII, Professional services, or the emolument of authors, inventors, and other professional and clerical classes. The interval between the doubling of the prices in these various classes of commodities or services, is not uniform; in other words, supposing eight years to be the time required for the entire doubling of prices and the classes of commodities and services to be eight in number, it would not follow that each successive year would add one to the classes with doubled prices. After once commencing to feel the influence of the increase of money, some classes will double in prices more quickly than others. Leaving this irregularity out of view; assuming that population and trade and therefore the demand of money remains unchanged; and supposing that no further increase of money or devices for enhancing its efficiency are brought into use; the precession of prices will appear somewhat as is shown in the following diagram:

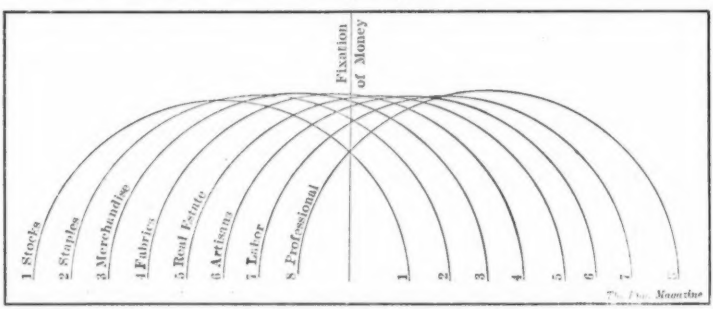


DIAGRAM OF PRECESSION OF PRICES DURING AN INCREASE OF MONEY.

At the point where money and credits become fixed in combined volume (both being reduced to the same ratio of velocity or efficiency) this diagram shows Stocks and Staples falling in price, while manufactured goods (Fabrics, and Labor) are still rising; both of these conditions being due to the same initial impulse.

Of course it will be understood that this diagram is not intended to represent or exemplify the actual condition of affairs at the present time, its sole design being to show that under the same influence, the prices of some classes of commodities or services may be falling, while others are rising: a phenomenon due to the precessional order in which they rise and fall under the influence of an increase of money which has ceased. The actual position of affairs is quite different. During the past eight years we have had an increase, chiefly of "National" bank notes, but far from a "doubling" of money. As nearly as can be made out from the very dubious "Circulation Statements" issued by the Treasury, which continue to overestimate the amount of gold "in circulation" by more than 500 millions, the per capita circulation of metallic and paper money is very little above what it was eight years ago; the effective increase of money being due more to activity than volume; more to the loaning of Treasury balances to the banks and to the use of improved devices for transmitting money and economizing its employment, than to any material increase in its amount.

On the other hand, the requirement for money to effect the purchases, sales, payments, and exchanges of the country has largely outstripped its population; a fact due to the universal employment of machinery in production. *Electricity has quickened industry; and industry needs more circulating money to effect its exchanges.* Capital wealth has increased from 88 to 115 billions; bank clearings from 88 to 175 billions; and products and commerce in like proportions. Last year the farmers received over five billions for their year's product; or more than twice as much as the entire currency of metal and paper. As for the requirement of the manufacturers, merchants, and carriers, it is many times as much. And yet all of this enormous series of exchanges has to be effected by means of a currency so ridiculously inadequate that had it not been eked out by the mechanical and financial devices of private persons, it would have plunged this rapidly growing country into very serious disorders. The events of 1837 to 1842 should not be entirely forgotten.

STOCKS. The fluctuations in stock quotations for railroad and industrial shares since January last are shown in the chart on page 27, taken from the New York *Times*, which added this comment:—

"The downward course of stocks since January 1 is well illustrated in the accompanying chart, the movement of sixty of the principal railroad stocks being averaged and indicated by the heavy line, that of ten industrials being averaged and indicated by the dotted line.

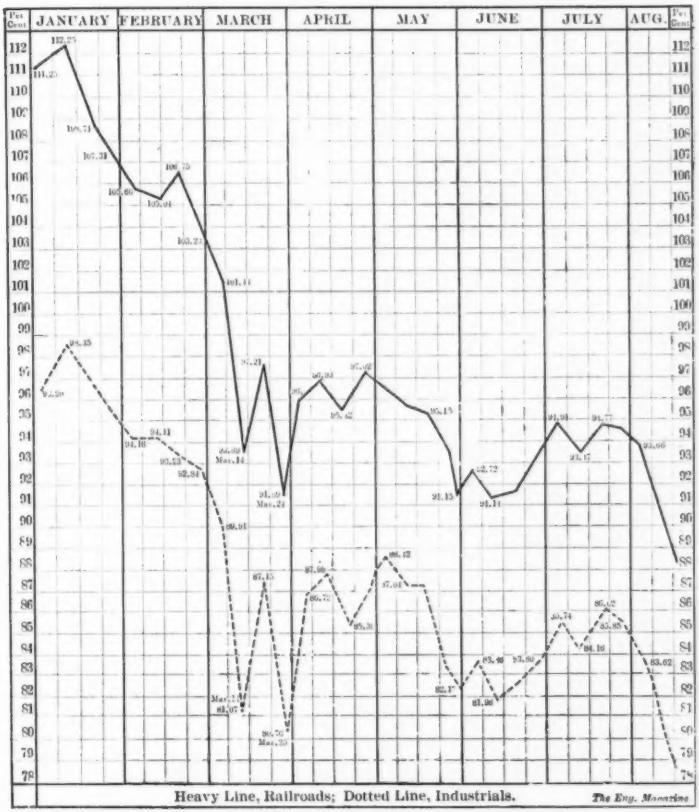
"It would be impossible, because of the confusion which would arise from the multiplicity of lines, to map the individual movements from day to day of each issue in which trading has been active on the Stock Exchange. The chart appended does not, therefore, show the violent fluctuations during the seven and a half months of such favorites of the professional trader as the Pacifics, Reading, Amalgamated, Great Northern, Steel, and Smelters. These and the score of other highly sensitive railroad and industrial stocks are toned down in the chart by association in their respective classes with the steadier stocks which go to make up the averages.

"It will be noticed how closely the general course of the ten industrials which have been averaged approximates the movement of the sixty railroad stocks."

Upon examining our classification of commodity prices it will be observed that the order of precession conforms to the marketability or ease of selling or exchanging, the various classes of commodities and services enumerated. The most marketable of all commodities are stocks; a fact which explains why, after having been the first to rise in response to increased money, they were the first to fall when the increase stopped.

Money. To increase money irregularly, is not merely to enhance all prices simultaneously; it is to enhance the price of some things in point of time before others; it is to benefit certain classes of the community at the expense of the remainder; it is to derange and throw into disorder all the varied and complicated interests of society. Contrariwise, to diminish its sum, or to permit it to diminish, or to neglect to increase it with the growing requirements of trade, is to depress the prices of certain commodities sooner than others, and to occasion a derangement of affairs even more perilous to the public welfare; for it so happens that, although theoretically labor benefits from a general fall of prices (it being the last in point of time to feel the effects of a paralysed currency) it practically suffers even more than during a general rise of prices; because a fall of prices hinders commerce and depresses production; and thus partially deprives labor of employment, or tangible existence.

The most cursory examination of the circulation will suffice to reveal its pinched condition and inadequate supply. As a matter of fact it consists entirely of paper notes and small change, whose combined sum does not exceed 2,000 millions. On August 1 the Treasury reported "Money in circulation, 2,781 millions; population 86 millions;



FLUCTUATIONS OF STOCKS, JANUARY-AUGUST, 1907. FROM THE N. Y. TIMES.

circulation per capita, $32." No such statement is required by law; it is not official; it is entirely voluntary; and it is false. There is no such amount of money in circulation; nor even is there so much money in the country. The statement includes 566 millions of gold coin, which are wholly fictitious. Last month, in deference to the oft-repeated objections to this item, the Treasury threw off 135 millions from its estimate of gold coin in circulation. It remains for it to throw off 500 millions more; it being a liberal estimate to assume that there are 66 millions circulating in a country where, except to a small extent in the Pacific States, gold coin is never seen at all. The Treasury may deceive the people, but it cannot deceive the dealers in bullion and foreign exchange; nor is there any necessity to deceive anybody. The credit of this country needs no such crutch.

The way this estimate is made up is to the last degree pathetic. The Director of the Mint innocently adds together the reports of production from the Wells-Fargo Express Company and of importation from the customs "entries," and from the quotient he deducts the reported exportations. The remainder, barring an estimated amount melted in the arts, is assumed to be "gold coin in circulation."

But the estimates of the express company, as shown in the Report of the Monetary Commission, include many duplications, and are unreliable. There is no penalty for understating or concealing bullion exports. Banking houses which deal in foreign exchange are not anxious to publish their bullion exports. Moreover, a great deal of gold is carried out of the country by travelers. Hence the returns of exports are deficient and misleading. A similar remark applies to gold consumed in the arts. The returns are non-compulsory, non-official, and largely deficient. These and other sources of error have been accumulated in the Treasury Statement of Circulation for eighteen years, with the result of creating an imaginary mountain of gold, where there is in fact only a molehill. Substantially, the only gold in the country is in the Treasury and the banks, and is not in circulation at all.

The 204 millions of silver dollars and subsidiary silver "in circulation" is also a mis-statement. This is doubtless the net amount coined and paid out, but much of it has gone to Cuba, Porto Rico, the Philippines, and even to South America and other foreign countries, where it can be seen doing active duty; but not in the exchanges of the United States. As to the 150 millions of gold reserve; the 146 millions loaned to the banks; the 33 millions of currency certificates included in the estimate of greenbacks in circulation; and various other items of this illegal and misleading account, we leave their discussion to the partisan press. Avoiding all disputable points and refraining from unessential detail, it is regarded a fair estimate to put the entire circulation at 2,000 millions, or about $24, instead of $32, per capita; a sum which at present prices is regarded as entirely inadequate to effect the exchanges of a country so extensive and busy.

In short, prices have grown up to the limits of the circulation, plus the cheque system, and the other devices of commercial credit and economy; a phenomenon which is quite sufficient to explain existing conditions, without recourse to chimeras. The remedy is in the hands of the Treasury, which for some unexplained reason is heaping up an idle balance of nearly 500 millions. When this War Chest is permitted to enter the exchanges, there is every reason to believe that the passing financial cloud will disappear.

THE MECHANICAL ENGINEERING OF THE MINE.

By Chas. C. Christensen.

The mine, as Mr. Christensen says, calls upon the mechanical engineer for co-operation throughout the entire range of his professional practice. Some of its leading demands—for power transmission, hoisting and haulage, electric service, and ventilation—have been discussed lately in this magazine. Another subject of prime importance in the same field—pumping—is treated elsewhere in this issue. Mr. Christensen therefore leaves it to the illustrations to suggest the interest of these applications of power, and devotes his text to a summary of methods and equipment employed in modern ore dressing and treatment.—THE EDITORS.

THE mechanical engineering of the mine is a broad subject and, if treated fairly, could fill volumes, but confined to the limited space of an article, one can only briefly depict the extent to which mining has come to depend upon machinery and the part which the mechanical engineer has played as expert associate with the mining engineer and mine owner in order to make mining a commercial success. The California miner of 1849 found only a shovel and a pick at his disposal, and with these ancient tools he started mining and was fairly successful. Soon, however, the mechanical, the civil, and the mining engineer came to his aid. The mechanical engineer brought him the air drill, the hoist, the deep mine pump, the stamp battery, and the ore crusher. The civil engineer gave him high explosives, and the mining engineer came and stayed with him, assayed his ore, and outlined better processes which in turn made the mechanical engineer design and invent newer and more suitable machinery.

Invention followed invention and when I arrived in the United States in 1879, a green graduate of an European college, I found as far east as Chicago all the work I could wish for, waiting in the mining-machinery branch.

In those old days machine shops devoted to the manufacture of mining machinery were few and small. The Pacific Coast shops were of course first in the field after the days of 1849. The Pelton Water Wheel Company had introduced its wonderful water wheel for high heads and small quantities of water. The Leffel Company in the East had brought to the mine the well designed Leffel water motor for low heads and large quantities of water, and the Rand Drill Company's air compressors and drills were opening up the mines both at home and abroad.

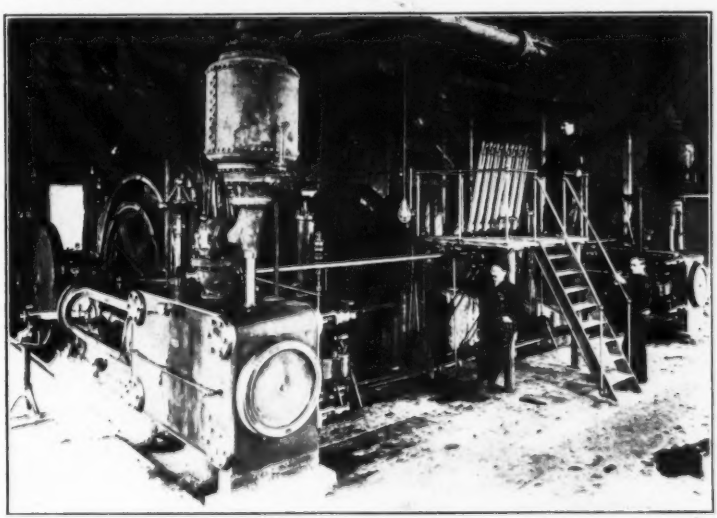
GROUP OF SULLIVAN 2¼-INCH PISTON DRILLS STOPING IN A COLORADO GOLD MINE.

The Gates Iron Works in Chicago started to make mining machinery in the seventies, and the famous Gates crusher, when it appeared, marked a new era in the mechanical engineering of the mine. The Edw. P. Allis Company in Milwaukee also early established a mining-machinery department, and their mechanical engineers can be proud of what they have contributed to the development of the mine. But it was Fraser & Chalmers who, in the early seventies, started a machine shop on the corner of Fulton and Union Streets, Chicago, exclusively devoted to the manufacture of machinery for the mine and smelter, and this Chicago corner became in the eighties the Mecca for mining men from all the States in the Union, as well as from many foreign lands. Inside the red walls of the plain building many a mechanical-engineering problem of the mine has been solved and many mining plants designed.

My first experience was to make the plans of the 120-stamp free-milling gold mill erected in 1879 at Lead City, Dakota (Black Hills) by the Highland Milling Co. This mill is what we may call a double 60-stamp mill, as it is arranged with two 60-stamp mills backing one another. The ore bins are placed in the center, tapering down to both rows of batteries and above the bins are located the crushers, the grizzlies and the car tracks. The plans were ordered on the large scale of ½ inch to 1 foot; consequently when making them, I had to lie on the 6 by 16 foot drawing board and handle a T-square as

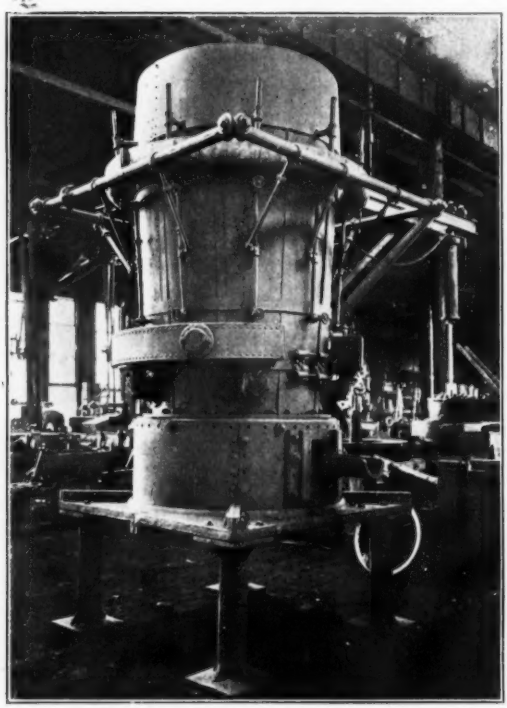
long as the table, but these drawings when completed, showed all details; and being made before the time of blue printing, they were colored and shaded in true European style. The next year (1880) a water-jacketed furnace was erected by the Hecla Consolidated Mining Company. It was a lead-silver furnace 36 by 60 inches in size at the tuyeres and was one of the first water-jacketed furnaces ever built. It had a 48-inch high cast-iron jacket made in sections suitable for transportation and for removal in case of repair. Compared with the furnace of today this first furnace was crude and clumsy, but I mention it here as it was, at that time, a great forward step in the mechanical engineering of the mine.

A number of furnaces were designed in the eighties with cast-iron jackets, because the first steel jackets built gave very little satisfaction; but it did not take many years before the steel jacket was perfected and today it reigns supreme. In the design of smelting furnaces, brick is at the present time used but little, and for copper furnaces it has been abolished altogether. Instead are used steel, cast-iron, and cast steel, from the bottom to the top, and a copper furnace of today is a marvel of mechanical genius. It is water-jacketed up to the charging floor, has water-jacketed aprons above at the charging openings, steel hood, stack and downtake, steel or cast-iron air or



DUPLEX DIRECT-ACTING DOUBLE-DRUM CORLISS HOISTING ENGINE, ALASKA-TREADWELL GOLD MINING CO.

Allis-Chalmers Co., Milwaukee.



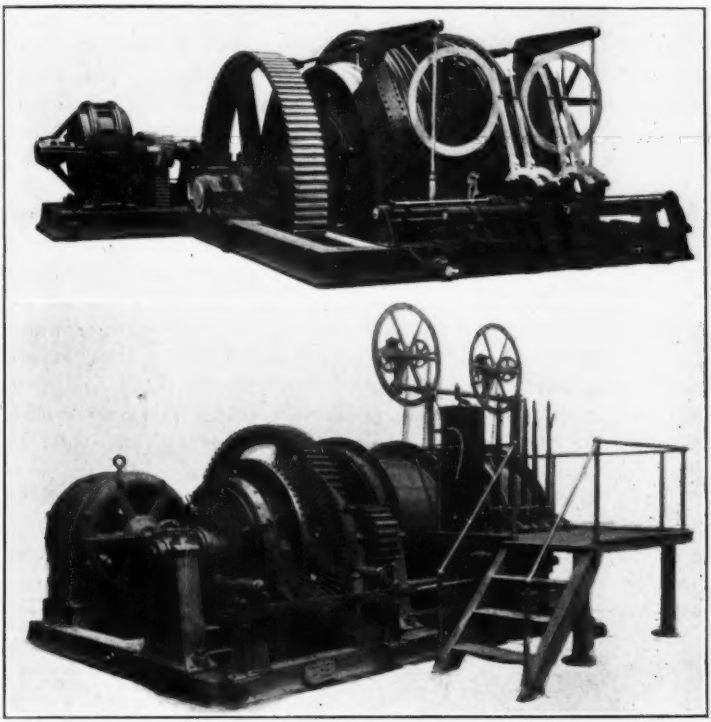
A 36-INCH SECTIONAL WATER-JACKETED COPPER FURNACE.
Allis-Chalmers Co., Chicago.

hydraulic-operated charging doors, heavy cast-iron crucible plate in sections, resting on short cast-iron columns, I-beam mantel frame supported by Z-bar columns carrying the cast-iron dumping plates and the whole superstructure.

The sizes of these modern furnaces run all the way from 36 by 84 inches to 56 by 612 inches, but though so perfect in design now, new ideas are springing up all the time and I am confronted with about a dozen new furnace designs every year.

Small, round water jackets are sometimes welded up in one piece or, if need be, made in sections for mule-back transportation. They are made in sizes from 20 inches diameter up to 48 inches diameter.

The old reliable stamp mill is perhaps among all apparatus the most standard piece of mining machinery in existence. It is as standard in the mining world as the high silk hat is in society circles, and like this headgear it has not changed much since it first appeared. Cast-iron anvil blocks, heavier stamps, shorter lifts, Blanton self-tightening cams, and sectional guides, are the improvements made so far. In the African mills stamps are used as heavy as 1,300 to 1,400 pounds and with 10 inches drop and about 100 drops per minute will crush 5 to 5½ tons per stamp per day of 24 hours. In Alaska at the Alaska Treadwell Gold Mining Company's Mills, stamps are 1,050 pounds and the capacity varies from 4.95 tons to 5.79 tons per



EXAMPLES OF RECENT AMERICAN MINE HOISTS.

By the Wellman-Seaver-Morgan Co. The upper is an electrically operated (a. c.) double-reel hoist for 2,000-lb. load on a 2,000-lb. skip from a depth of 1,200 ft. at 500 ft. per minute; friction clutches, post brakes, and automatic safety device against overwinding. The lower is the latest type of double-drum electric hoist for balanced cage hoisting, operated by continuous speed a. c. motor. The operation of the drum is reversed by two bevel gears controlled by band friction clutches.

stamp per day. In the Black Hills most mills have 850-pound stamps and crush 4½ tons per stamp per 24 hours at an average. This record, however, has been broken by the 2-stamp 4-screen opening mill, which at the Tenero Mining & Milling Company's plant crushes up to 6 tons per stamp per day through 24-mesh screens.

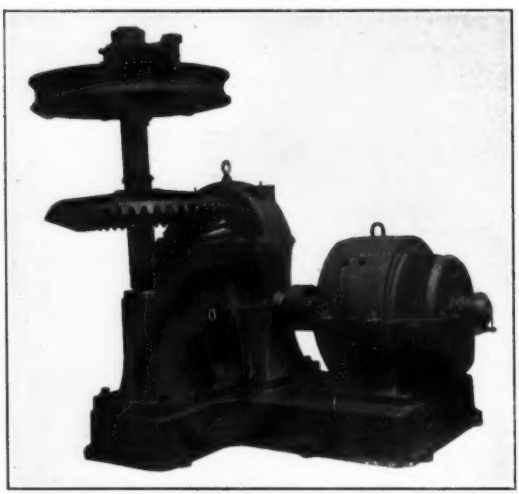
The Tremain steam stamp has been designed especially to meet the demand of those who own mining properties in the first stages of development, enabling them to establish a thoroughly good crushing, amalgamating, or concentrating plant of moderate capacity.

The Tremain steam stamp consists of two 300-pound stamps,

the stems of which terminate in pistons working in cylinders like a steam engine. The speed is 200 or more drops per minute and the capacity of the mill varies with the character of the ore and size mesh of screen from 8 tons to 20 tons per day of 24 hours, or 4 to 10 tons per stamp per day. The three-stamp prospecting mill for free-milling ore, consisting of a battery of three 250-pound stamps, is very popular. It has been designed to meet the demand for a light, compact plant, capable of being easily and quickly taken apart, transported on mule-back, and erected where desired. The mill is driven by a 3 horse-power combined vertical boiler and engine.

Heavy steam stamps, of which one will reduce as much ore as an ordinary 60 to 100-stamp mill, are in operation in the United States as well as abroad. The stamp is driven by a vertical steam cylinder with valve gearing designed to keep the top steam port fully open during the down stroke, adding the power of steam to the weight of the stamp, while for the work of the up stroke—merely lifting the stamp—a small steam admission suffices.

The Krause atmospheric stamp is a machine operated from any source of power by pulley and crank-shaft. This crank-shaft is connected by means of a connecting rod and crosshead to the upper piston in an air cylinder. The upper end of the stamp shaft forms the lower piston. As the upper piston starts to rise, a partial vacuum is created between the pistons which raises the lower piston and stamp shaft. A tappet on the stamp shaft coming in contact with a horizontal lever raises a vertical stem, which opens an inlet valve, thus admitting atmospheric pressure between the pistons. The lower piston and stamp shaft



BEVEL-GEAR ENDLESS-ROPE HAULAGE SET.
90 horse-power; driven by 550-volt enclosed multipolar motor.
J. H. Holmes & Co., Newcastle-on-Tyne.

continue their upward movement until arrested by a cushion of high initial pressure, caused by the down-coming upper piston, which drives the stamp down with a rapidly increasing movement until at the end of the stroke the stamp has attained a velocity of 1,200 feet per minute and delivers a very powerful crushing blow. The speed of the stamp is 190 blows per minute and it will crush hard 1½ to 2-inch size copper-bearing rock at the rate of 2½ tons per hour through a 16-mesh screen.

The Gates crusher has been an important factor in the development of the mine. It is a rock and ore-breaker of the gyratory form. The crushing is done between a cone placed on a gyratory shaft vertical through the center of a cylindrical shell. As it gyrates the crushing cone impinges against the sides of the shell in relation to which it is constantly approaching and receding. The top of the shaft carrying the crushing cone is held rigid while the bottom is gyrated with a certain amount of eccentricity by means of a single gearing. The crusher is built in about a dozen sizes and the capacity per hour, in tons of 2,000 pounds passing a 2½ inch ring, runs all the way from 2 to 200 and over.

The best-known and most successful crushers of the jaw type are the Blake stone and ore crusher and the Dodge crusher. Blake and Dodge crushers affect the reduction of the material between two jaws, protected from wear by removable plates. One of the jaws is stationary and the other movable. In comparing the relative merits of the two machines, it is obvious that as the width between the jaws at the point of discharge in the Dodge crusher remains more constant, a finer and more uniform product can be obtained than from the Blake, but it is inferior to the latter in capacity.

Dodge crushers are admirably adapted for the reduction of the product of a gyratory breaker adjusted for coarse work, the fine, even product thus obtained being very suitable for feeding rolls or any other kind of pulverizers. For the preliminary crushing of ore in stamp mills of small or medium capacity, Blake crushers have been extensively used and with very good results. The Blake and the Dodge crusher are built in respectively six and four sizes and their crushing capacity runs from 4 to 24 tons per hour, 1½-inch size, for the Blake type and from 1 to 8 tons nut size for the Dodge.

The several types of stamp mills, and other mining plants, now in successful operation, may be sketched as follows:—

A.—Stamp Mill for Free-Milling Ore. Free gold is caught on the inside copper plates of the mortar and the outside copper tables in front of the stamp batteries, by means of quicksilver, forming

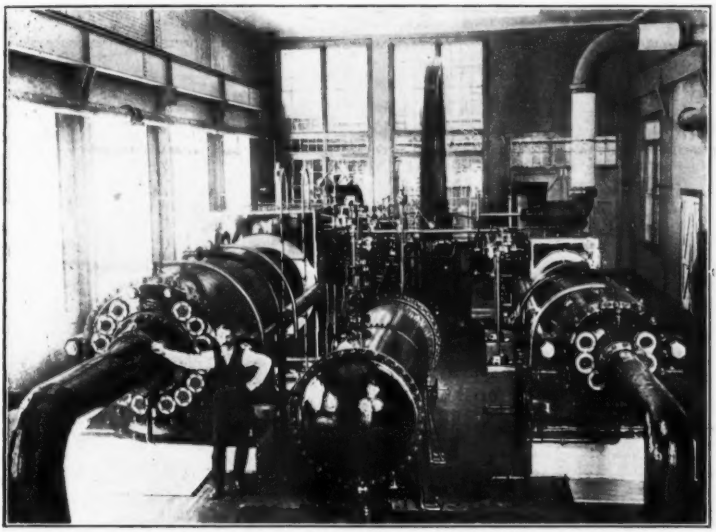
gold amalgam, which at intervals—about twice a month—is scraped off and retorted, vaporizing the quicksilver which is then condensed in water. The gold thus gained is melted and runs into moulds, while the quicksilver is saved and used over again.

The machinery for such a mill consists of: crusher, stamp feeders, which receive the ore from the bins and feed it into the mortars; stamps, lifted by cams; copper tables, and for a large mill, a clean-up pan in which the amalgam when dirty and impure is worked with additional quicksilver and the waste matter washed off before retorting. The camshaft of the stamp battery generally runs 45 to 50 revolutions per minute and by the double cams the stamps are lifted and drop by gravitation 90 to 100 times per minute.

B.—Stamp Mill with Concentrators or Frue Vanner Mill. Most gold ores will yield only a portion of their contents to the plain amalgamating process outlined above, because some of the precious metals is tied up in combination with sulphides and baser metals. Values in this form are generally saved by adding concentrators—the Frue vanner type of which have given excellent result in close competition perhaps with the Overstrom table and the Wilfley table. The Frue vanner consists of an endless flanged rubber belt 4 to 6 feet wide and 12 feet long. The belt travels up an incline and round a lower drum which dips into a water tank in which the mineral is collected. In addition to the travel of the belt the latter receives a steady shaking or settling motion from a crank shaft along one side of the machine, the shake being at right angles to the inclination and travel of the belt. The ore is fed upon the belt in a stream of water about 3 feet from the head, and flows slowly down the incline, subjected to the steady shaking motion which deposits the mineral on the belt. At the head of the belt is a row of water jets. The slow travel of the belt brings up the deposited mineral and the water jets wash back the lighter sand, letting only the heavy mineral pass and become deposited in the water tank below.

The machinery for a vanner mill is the same as for a free-milling ore mill, with the consentrators added.

C.—Wet-Crushing Silver Mills. The ore brought in by cars at the top of the mill is dumped over the inclined grizzly or screen and rolls onto the crusher floor. All the small pieces pass through the screen or grizzly into the ore bins underneath. The coarse rock is shoveled into the crusher from the floor, which is on a level with its charging hopper, and is crushed to the size of walnuts, falling into the ore bins, whence it passes into automatic stamp feeders through inclined chutes controlled by ore gates.



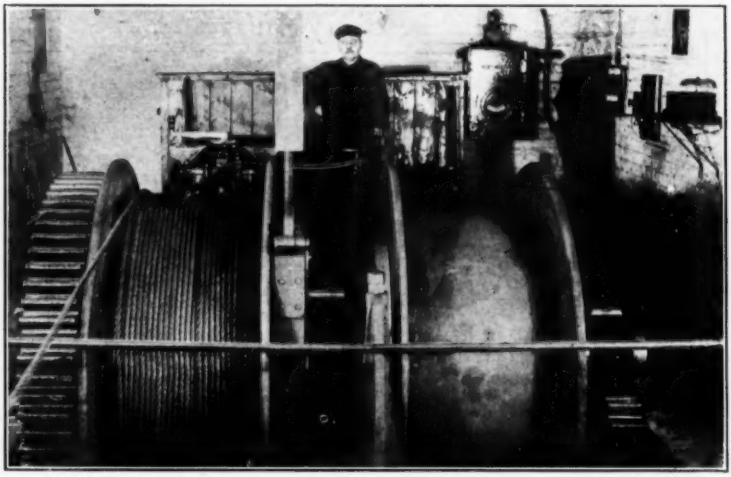
THE LARGEST AIR COMPRESSOR IN THE WORLD. HOMESTAKE GOLD MINING CO., LEAD, S. D.

Steam cylinders 32 and 60 in.; air cylinders 52¼ and 32¼; stroke 72 inches. One of seven Ingersoll-Rand compressors used by the Homestake Co.

The finely stamped ore suspended in water, and known technically as pulp, flows into large settling tanks, where excess of water is drawn off. The thick pulp remaining is shoveled in regular charges into a row of amalgamating pans, in which it is worked several hours, first with salt, bluestone and other chemicals, then with addition of quicksilver. The contents of the pans are run into large settlers placed below and in front, in which the pulp is thinned by addition of water with gentle agitation and all the quicksilver, with precious metals in the form of amalgam, is settled to the bottom. The pulp is gradually run off from the settler and flows to waste. The amalgam is strained from excess of quicksilver, retorted to drive off the remaining quicksilver, and the silver and gold is melted into bars. Generally two 5-foot pans and one 8-foot settler are supplied with each 5-stamp battery. Most mills are also provided with a quicksilver system for elevating and distributing quicksilver throughout the mill automatically. The machinery for a wet-crushing mill would be:—crusher, stamp feeders, stamps, settling tanks placed in front of the stamp battery, pans, settlers, amalgam safes and strainers, retort, and bulletin furnace. When the Boss continuous process for amalgamation is used, the pulp flows direct from the battery through

pipes to special grinding pans and is from there conveyed to the first amalgamating pan and flows continuously through the line of pans and settlers. The tailings are run off or led over concentrators.

The quicksilver is charged in the pans by means of pipes from the distributing tank and the amalgam flows through suitably arranged pipes to the strainer. The chemicals are supplied to the pans by two chemical feeders. The main line shaft runs directly under the pans and settlers, each of which is driven from it by a friction clutch. All the water from the battery must pass through the pans, so that all slimes are treated.



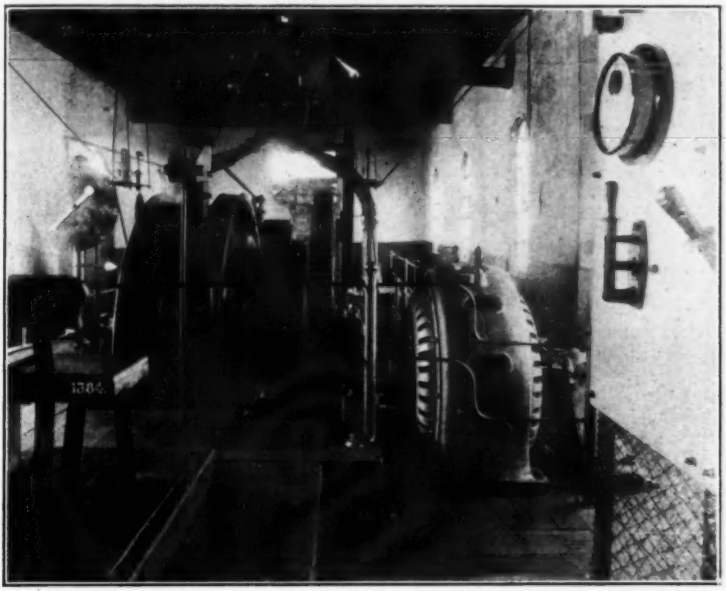
ELECTRICALLY OPERATED MAIN AND TAIL HAULAGE, WEST STANLEY COLLIERY, DURHAM.

Driving motor of slip-ring induction type, 500-volt, for three-phase 40-period circuit. Controller of reversing drum type. The British Westinghouse Co.

D.—Dry-Crushing Mills. When ore is base and needs roasting and desulphurizing before amalgamation can be successful, a modification of the wet-crushing mill is necessary. After passing the rock crusher, the ore is dried by passing through a continuously revolving dryer, located beneath the crusher. The dried ore is then taken by a car, or run in chutes if height will admit, to the automatic feeders, which feed the stamps while the ore is still hot. The pulverized product from the stamps is conveyed by screw conveyors to an elevator, by which it is carried to an iron storage hopper above. From here another conveyor conducts the pulverized ore to the roasting furnace in the furnace room. The roasting furnace may be a Howell-White, reverberatory, Bruckner, or Brown, Wethy, Ropp, Jackling,

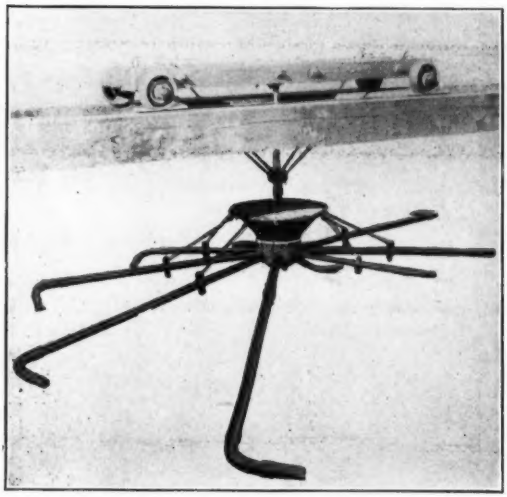
or McDougal furnace. In the furnace, the ore, with the addition of common salt, is desulphurized and chloridized, thus preparing it for the pans and settlers. After roasting, the ore is allowed to remain in pits to continue the chloridizing and afterwards is spread on a cooling floor and is taken as required to the pans. Amalgamation follows then on the same plan as in the wet-crushing mill.

E.—CYANIDE PLANT. The ore upon arriving in cars is dumped into a bin, whence it is drawn to feed a crusher. This machine reduces the ore to a maximum size of 1 inch, and discharges it into a revolving dryer, which thoroughly dries the ore so that the screens may be worked to their full capacity. The ore passes from the dryer



ELECTRIC WINDING GEAR, WITH TWO DRUMS FOR TWO DIFFERENT LEVELS.
Large drum 8 ft. 3 in., smaller 5 ft. 8 in., the levels being 180 and 120 feet; 80 horse-power motor, three-phase alternating current. Ernest Scott & Mountain, Gateshead-on-Tyne.

into a special fine crusher and is reduced to ¼ inch maximum size. The fine crusher discharges into an elevator, which carries the ore to a double shaking screen arranged in such a manner that the stream of ore may be instantly diverted to either screen. A gentle shaking motion is imparted to them by simple mechanism. The rejections from the screen are returned to the fine crusher for recrushing; that portion passing through the meshes of the screen is spouted to the crushing rolls to be reduced to the size required. From the rolls the



BUTTERS DISTRIBUTOR FOR CYANIDE TANKS.

ore is elevated and passed over a second double shaking screen and into the storage bins. The rejections from the screen are spouted back to the rolls.

The finished product, generally 30-mesh size, may now be drawn from the bins into small scoop cars standing on the platform scales and the contents of the cars weighed. A suspended track is constructed over the percolating tanks, by means of which the cars may be dumped directly into the tank. The ore is then leveled with a hoe, but a method producing more even percolation is to charge the tanks by means of the Butters distributor. This distributor consists of a hemispherical bowl, the top of which is covered with an iron sieve or grating. Into this bowl are inserted from eight to sixteen pieces of steel pipes of different lengths, the outer ends of which are bent at right angles horizontally and terminate in flattened nozzles, the whole being supported on an iron column in the center, or suspended from a light traveling crane running the whole length of the tank room. The centrifugal action of the discharging water causes the device to revolve slowly, thus equally distributing the charge.

The tailings from the percolating tanks are shoveled into cars and cast upon the dumps.

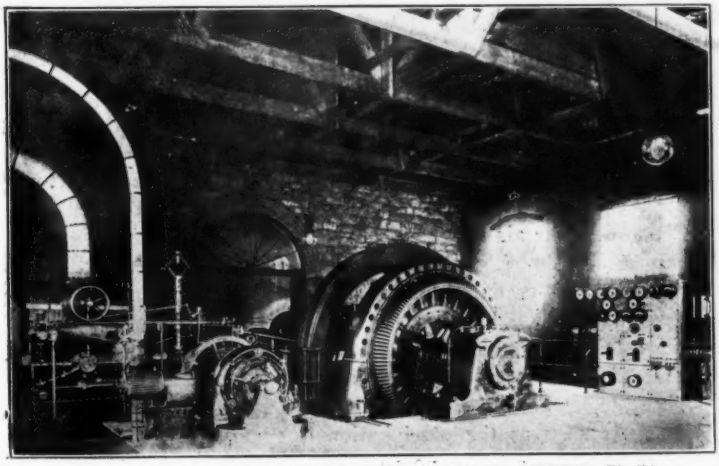
In a so-called cyanide tailings plant, the crushing machinery mentioned above is left out, the tailings being conveyed from the battery directly to the cyanide tanks. The tanks used in cyanide plants are generally made of steel plates and angle steel in sizes to suit the capacity of the plant. The percolating tanks are sometimes made as large as 40 feet in diameter by 5 to 8 feet deep. The time of percolation varies according to the character of the ore from 2 to 6 days.

F.—Chlorination Works. The ore, after being crushed, dried, screened, recrushed by rolls and roasted—see different types of

roasters above—is spouted to the cooling floor. After the ore has become sufficiently cool it is conveyed to an elevator which delivers it to the bin situated over the chlorinating barrels. From this bin, it is drawn into a car and weighed, after which it is ready for charging the hopper over the barrels.

The chlorinating barrels are generally of five tons capacity each. They have two charging doors or manholes, and a filter secured opposite the charging doors; the filter should be level when the barrel is in such a position that the doors are up, or on top. These barrels have under favorable circumstances, handled as much as eight charges of 5 tons each per day of 24 hours.

The barrels are charged first with the requisite amount of water; then sulphuric acid which settles immediately on the bottom; after which the ore is added, and lastly chloride of lime. The charging doors are securely fastened and the barrel revolved. The mixture of the acid and chloride of lime which occurs when the barrel is revolved, causes a rapid evolution of chlorine gas which soon produces a pressure in the barrel. Chlorine gas under slight pressure combines readily with water and rapidly chloridizes the metals present. After chlorination is completed, the barrel is stopped with the charging doors up, so that the filter will be level. Connection by hose is then made between the water tank, (which is elevated enough to give 50-pounds pressure) and the top of the barrel; a connection is also made between the lower portion of the barrel and the settling tank.



ELECTRIC POWER HOUSE, MCKELL COAL & COKE CO., KILSYTH, W. VA.
Allis-Chalmers 26 by 42 engine and 500-kilowatt 25-cycle 3-phase 6,600-volt generator.

The fresh water under pressure, entering on top of the charge, absorbs all free chlorine gas remaining after the ore has been chlorinated and forces the solution through the filter, and thence through the pipe leading to the settling tanks.

ELECTRIC ROOM AND PILLAR UNDERCUTTING MACHINE IN AN OHIO MINE.

Adapts longwall principle to room and pillar work, making a continuous cut across the face without withdrawal until room is finished. Sullivan Machinery Co., Chicago.

The solutions containing gold are allowed to settle for some time, after which the clear solution is drawn off into the storage tanks. From the storage tanks the solutions are pumped into the precipitating tanks which are situated about 25 to 30 feet above the filter press, thus generating the necessary pressure to force the solution properly through the press. The precipitation of gold from the solution is now to be accomplished. Gas generators are placed level with the top of the precipitating tanks. One is a closed vessel in which the sulphur is burned, while air under pressure is forced through it from an air compressor. Another generator is lined with lead, in which hydrogen sulphide is produced. The precipitating tank being full of chlorine solution, the SO_2 generator is put into commission and sulphurous acid gas forced through a hose, to the bottom of the tank. The H_2S generator is charged with iron matter and diluted sulphuric acid. When the compressed air is admitted the gas is conveyed to the solution. As soon as the precipitation is completed, the generator is stopped and the solution now settles for about an hour after which time it is passed through a filter press which collects the sulphides.

After the solutions have passed through the filter press, air under pressure is forced through and partially dries the sulphide cake, which is now placed in iron trays in large cast iron mufflers, roasted, fluxed, fused, refined, and cast into bars.

The machinery required for chlorination mill would be: crushers, dryers, revolving screens, rollers for recrushing and any type roaster; elevators, chlorination barrels, cars, platform scales, steel water tanks, precipitating tanks, solution pumps, gas generators, air compressor, filter presses, iron trays, and cast-iron muffler.

G.—Concentrating Plants. Concentration is classed either as coarse or fine, terms relating primarily to the size of the material, whether granules if coarse, or slimes if fine.

Coarse concentration deals with the coarse or partial crushing of the ore, sizing in revolving screens or trommels and hydraulic classifiers, and treatment upon jigs (eccentric-driven plungers forcing water constantly through the ore placed on stationary screens or grates) which yield a product of clean or valuable concentrates.

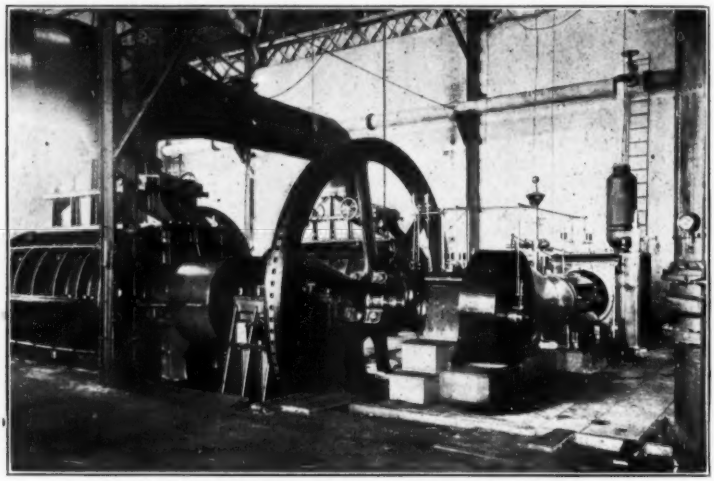
Fine concentration, by concentrating tables, often follows the coarse, when it includes the treatment of the finer residual products of coarse concentration, or the ore may be crushed fine at the outset.

Concentrating ores with values chiefly of copper, zinc, lead, tin, or iron are generally treated by coarse concentration, but gold and silver-bearing ores, contain most of the precious metal in a fine state, and are therefore subject to fine crushing and concentration.

H.—Hoisting and Pumping Works. From the small horse-power hoist or whim, where, with one horse walking, 400 pounds of ore can be lifted 60 feet per minute, the mechanical engineer has co-operated with the miner in developing the modern powerful duplex direct-acting double-drum Corliss hoisting engine, with high-grade hoisting cages and safety appliances.

At the pumping works, the old Cornish pump, which in the eighties was so popular, has now, at most mines, been replaced by the modern, steam and electric-driven deep mine pump, of higher efficiency. The engineer in providing for the drainage of a mine, and after fixing upon the capacity and lift, has two things chiefly to bear in mind: First, the commercial efficiency of installation, considered with due reference to the mining risk and the length of time that the plant will probably be in use; second, the safety against "drowning out" that the plant should afford. To judge from the many modern installations of mine pumping plants, the points referred to above have been duly considered and successfully solved, and the mine pump of today is a fine piece of engineering.

I.—Smelting Plants. To melt or fuse ore for the purpose of separating the metal from its gangue is called smelting. It consists in subjecting ores and suitable fluxes to the action of intense heat, whereby the materials become fluid, the fluxes combining with the gangue of the ore to form a slag, while the valuable parts combine together to form a matte, the separation taking place while the materials are in a molten condition, by difference in their specific gravity.



ROOT BLOWER FOR BLAST FURNACE, ANACONDA MINING CO.

Blast Furnaces for Silver-Lead Ores.—The general form of the blast furnace for silver-lead ore is a rectangular brick shaft bound with iron, resting on an I-beam mantel frame supported at the four corners by columns, generally made up of four Z bars. Below this shaft are the water jackets made of flanged steel plates. The side jackets have openings for tuyeres, a short distance from the bottom. The jackets rest on a curb of fire-brick enclosed in a steel or cast-iron frame, and in the center of this curb is a large cavity, named the internal crucible, from which the lead is removed through the syphon tap. The smallest standard steel water-jacketed furnace designed is 20 inches inside diameter—a combined lead and copper furnace. The jacket, made in one piece by welding, is hung from the charging floor, which permit the curb being removed without disturbing any other part of the furnace. This furnace has an approximate capacity from 8 to 10 tons per day of 24 hours. Round silver-lead furnaces 36 and 48 inches are very popular sizes for smaller smelting plants, and these sizes are also designed and built in sections for mule-back transporta-

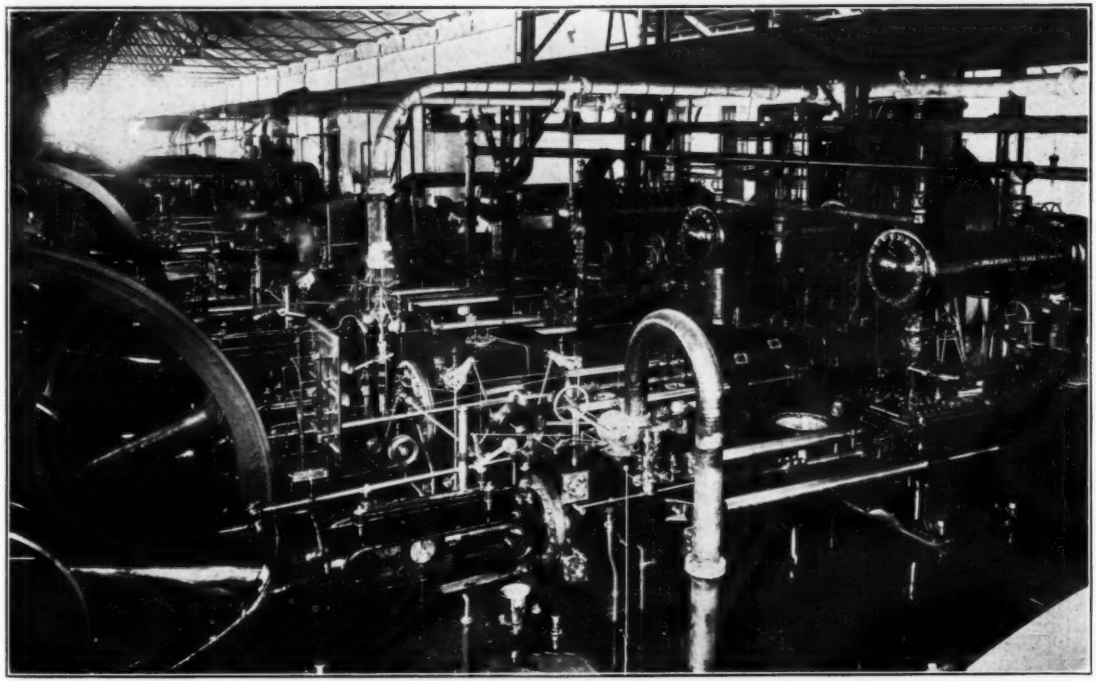
tion. The rectangular silver-lead furnaces are designed and built in many different sizes and to suit all kinds of local conditions; 33 by 72 inches, 36 by 100 inches, 36 by 120 inches, 36 by 160 inches and 40 by 96 inches—a good average 100-ton furnace; 42 by 120, 44 by 160, and 44 by 168 inches are the most common sizes.

BLAST FURNACES FOR COPPER ORES.—These furnaces differ considerably from those used for silver-lead ores. The steel jackets are generally made in two tiers and extend up to the charging floor. The internal crucible is dispensed with altogether and the jackets rest upon the heavy cast-iron crucible plate supported on jackscrews or columns.

A very popular size of the round type is the 36 inch inside by 6 feet 6 inches high, single water-jacketed furnace, having a capacity of about 30 tons per day of 24 hours. Such a furnace needs about 1,820 cubic feet of blast per minute, and the nearest blower of the iron-impeller—top-discharge—type would be one having a capacity of 9 cubic feet per revolution and running 220 to 225 revolutions per minute. Other items for such a small copper-smelting plant would be: Six slag pots and trucks, three bullion pots and trucks, two large settling pots and trucks, one 4-beam charging scale, one steel charging barrow, one coke barrow, six tubular steel wheelbarrows, one coke fork, one scoop shovel, six long-handled steel shovels, two sledges with handles, 300 pounds of steel furnace bars; a 12 horse-power engine and boiler, or electric motor attached to the blower to run it direct is all the power needed. The rectangular types are built in 36, 42, 44, 48, 54 and 56 inches width and in lengths up to 612 inches or 51 feet.

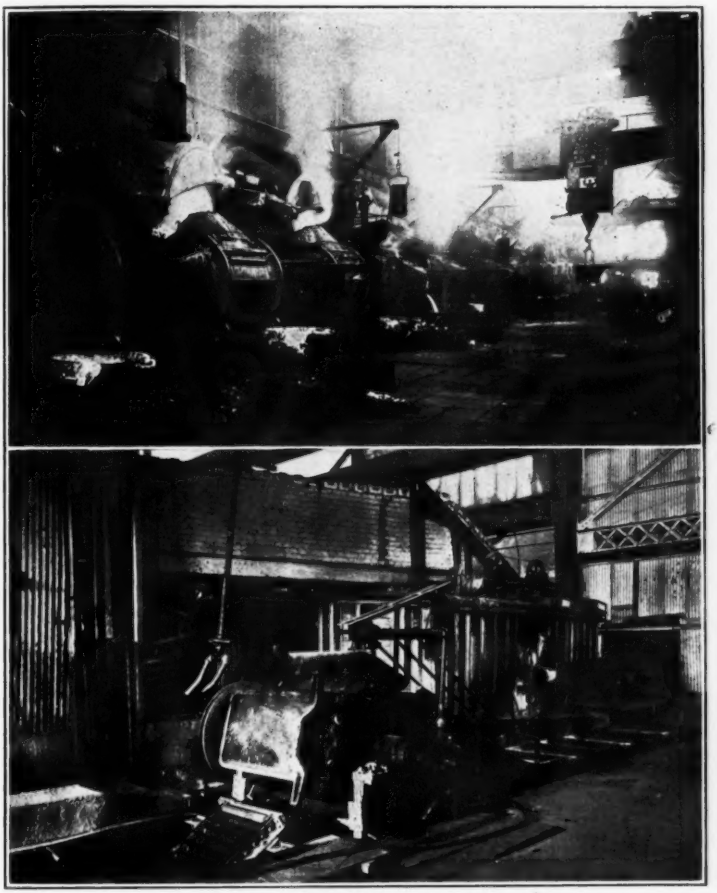
J.—COPPER CONVERTER PLANTS. To bessemerize copper matte, which consists mostly of copper, sulphur and iron, is to convert it into metallic copper by slagging off its iron contents and burning off its sulphur.

The process is performed in a steel vessel very similar to that used in the bessemer steel process, and said vessel is called a converter. It has a thick lining of crushed quartz in which is mixed a sufficient quantity of clay to hold the quartz together. On one side, near the bottom of the converter, is attached an air box, which supplies air to a number of horizontal tuyeres or holes pierced through the lining. Molten copper matte is charged into the converter and air from a blowing engine under a pressure of from 6 to 15 pounds is forced through the molten mass. The iron is oxidized and united with the quartz of the lining to form a slag, while the sulphur combines with the oxygen of the air, forming sulphurous acid gas, which



INTERIOR OF SMELTER POWER HOUSE, SHOWING COMPRESSORS, ANACONDA MINES.

Fifteen 4-stage Ingersoll-Rand compressors; steam cylinders 20 and 40 in., air cylinders 37¼, 20¼, 12½ and 6 in.; stroke 48 in. Capacity 2,000 ft. of free air per minute. Pressure 950 lb.

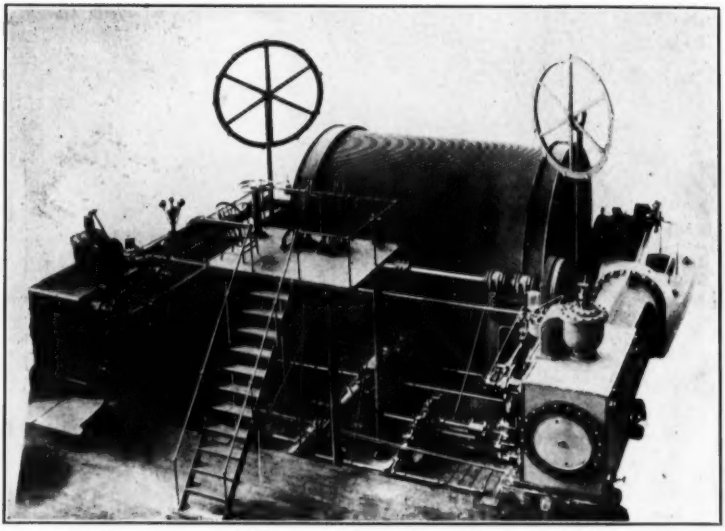


PORTIONS OF THE ANACONDA SMELTING PLANT.
Above, the converters, served by a 60-ton electric traveling crane. Below, the Straight Line casting machine for copper

escapes. The slag is skimmed off and returned to the blast furnace, and the metallic copper is poured into moulds.

In this operation no fuel is used, the heat being supplied by the combustion of the sulphur in the matte. The lining is rapidly eaten out—in fact, the operation is performed at the expense of the lining, and after a small number of operations, the converter shell is taken to the relining room to be relined.

The shells of the converter are made of heavy steel plates, heads



SULLIVAN CORLISS HOIST FOR CENTENNIAL COPPER CO., CALUMET, MICH.
Capacity 4,000 ft. depth; speed 3,500 ft. per minute; drum 15 ft. diameter. Engines 32 by 60. Sullivan Machinery Co.

and top of cast steel, supported on a cast-iron stand with flanged rollers; the converter is tilted either by hydraulic machinery or by gears and an electric motor attached to the stand. The converter shells are generally handled by an electric traveling crane and the air is furnished by a blowing engine of the Reynold or Nordberg type or by the Parsons steam-turbine blower. A Chilean mill is used in the relining room for grinding clay for the converter lining.

The converters are designed and built in different sizes 72 inches diameter by 100 long, and 84 inches diameter by 126 inches long being the most common. The "blows" per 24 hours run from 10 to 16.

The tuyeres are provided with the Dyblie tuyere valves and most converters nowadays have attached the Bennett pouring spoon. Trucks made of steel beams supported on four wheels carry the moulds when they are pushed under the converters to receive the blister copper.

THE MANUFACTURE OF STEEL AND WROUGHT IRON IN AMERICA.

By Bradley Stoughton.

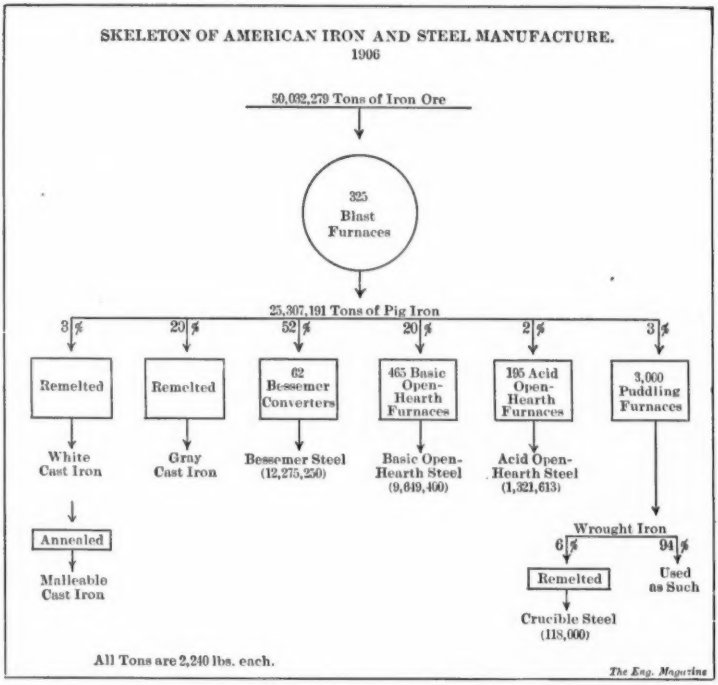
The three metals most interesting from an economic point of view—always, but especially just now—are steel, copper and gold. Of these the first is the most closely interwoven with the development of engineering construction in every line. Professor Stoughton treats the American steel industry in its metallurgical rather than its economic aspects, and like the authors preceding him in this issue he brings to the discussion the equipment of a specialist with a record of creative professional work in his own department.—THE EDITORS.

IRON, as first obtained from its ores in the form of a commercial product today, appears almost wholly in the form of "pig."

The large amount of carbon in pig iron, however, makes it both weak and brittle, so that it is unfit for most engineering purposes. It is used for castings that are to be subjected only to compression, transverse, or very slight tensile strains, as, for example, supporting columns, engine bed-plates, railroad car wheels, water mains, etc; but the relatively increasing amount of steel used shows the preference of engineers for the stronger and more ductile material. To-day three quarters of the pig iron made in the United States is subsequently purified by either the Bessemer, open-hearth, or puddling process. Each of these will reduce the carbon to any desired point, while the silicon and manganese are eliminated as a necessary accompaniment of the reactions—indeed, we might almost say, as "a condition precedent" to carbon reduction. Phosphorus and sulphur are reduced by the puddling process, and by a special form of open-hearth process known as "the basic open-hearth process."* The complete scheme of American iron and steel manufacture is given on page 50.

The figure expresses graphically data which are interpreted at greater length as follows: Practically all the iron ore mined is smelted in about 325 blast furnaces, to produce annually 25,000,000 tons of pig iron. About 3 per cent of this pig iron is remelted and made into malleable cast iron; 20 per cent is made into gray cast iron; 52 per cent is purified in 62 Bessemer converters to Bessemer steel; 20 per cent is purified in 465 basic open-hearth furnaces; 2 per cent is purified in 195 acid open-hearth furnaces, while the remaining 3 per cent is purified in 3,000 puddling furnaces to make wrought iron. Only active furnaces are included, and the numbers are estimated

* The basic Bessemer process is not in operation in America.



as the recent statistics are not yet published.* The wrought iron may be used as such for pipe, blacksmith work, small structural shapes, etc, and 94 per cent of it is so used; the other 6 per cent is remelted in crucibles to make crucible steel. To sum up, about 23 per cent of the pig iron made is used without purification,† and 77 per cent is purified and converted into another form. In all cases of purification the impurities are removed by oxidizing them, and we must emphasize the rule of all smelting that unoxidized elements dissolve in the metal, while those in the oxidized condition pass into the slag, or, if there is no slag, form a slag for, and of, themselves. In considering the Bessemer, open-hearth, and puddling processes, then, we have to do with oxidizing conditions, whereas the opposite is the case in the blast furnace. The oxidization is effected by means of the

* The numbers and percentages given in this Figure will change slightly from time to time, but this will convey an idea of the relative amounts of the different products made.

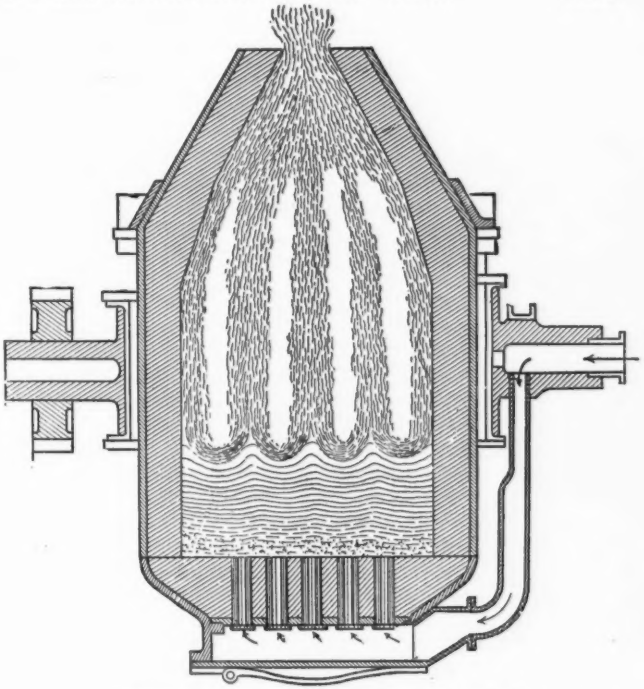
† It is true that the annealing process for malleable cast iron purifies the outer layers of the castings from carbon, and, if the castings are very thin, this purification may extend to the centre; but this is not primarily a purification process and will be treated at length in another section.

oxygen of the air or that of iron ore, Fe_2O_3, or its equivalent, or of both air and oxide of iron.

There is not an exact relation between the amounts of pig iron used for the different purposes and the amounts of the resulting materials. In 1906 the following production was made:—

TABLE I.

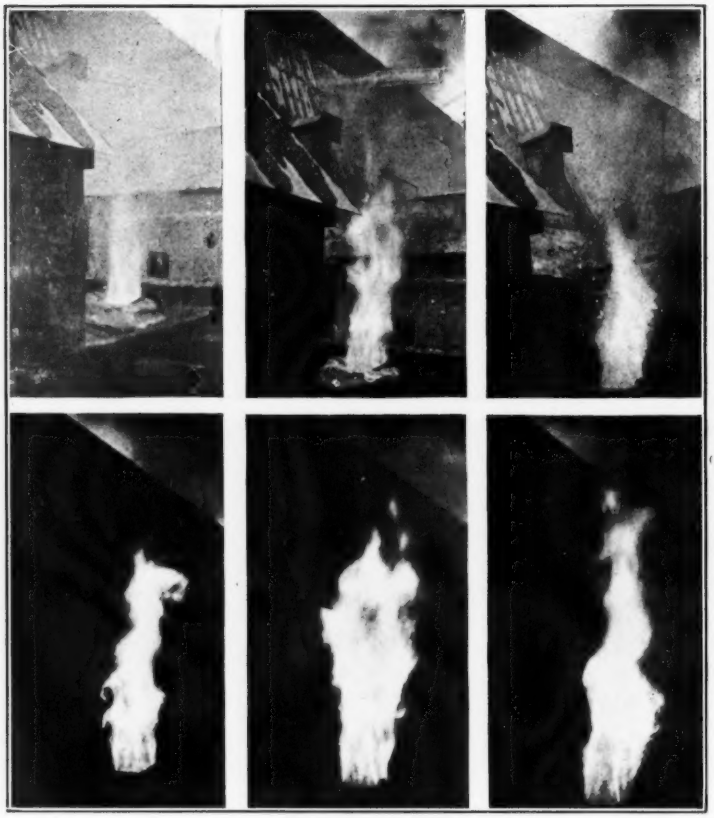
	Cast Iron Used.	Made.
Malleable Cast Iron	600,000* tons	750,000* tons
Gray Cast Iron	5,100,000 "	6,000,000 "
Bessemer Steel	13,150,000 "	12,275,250 "
Basic Open-Hearth Steel	5,150,000 "	9,649,400 "
Acid Open-Hearth Steel	500,000 "	1,321,613 "
Wrought Iron	800,000 "	2,000,000* "
Crucible Steel	.....	118,000 "



SECTION OF BESSEMER CONVERTER IN ACTION.

The cause of the descrepancy is the scrap iron or steel mixed with the pig iron in the manufacture of gray-iron castings and open-hearth steel. Perhaps an average of 25 per cent of old scrap will be mixed with 75 per cent of new pig iron for making iron castings, and 50 per cent or so of steel scrap will be mixed with 50 per cent of so of

* These are as close estimates as can be made in the absence of exact statistics.

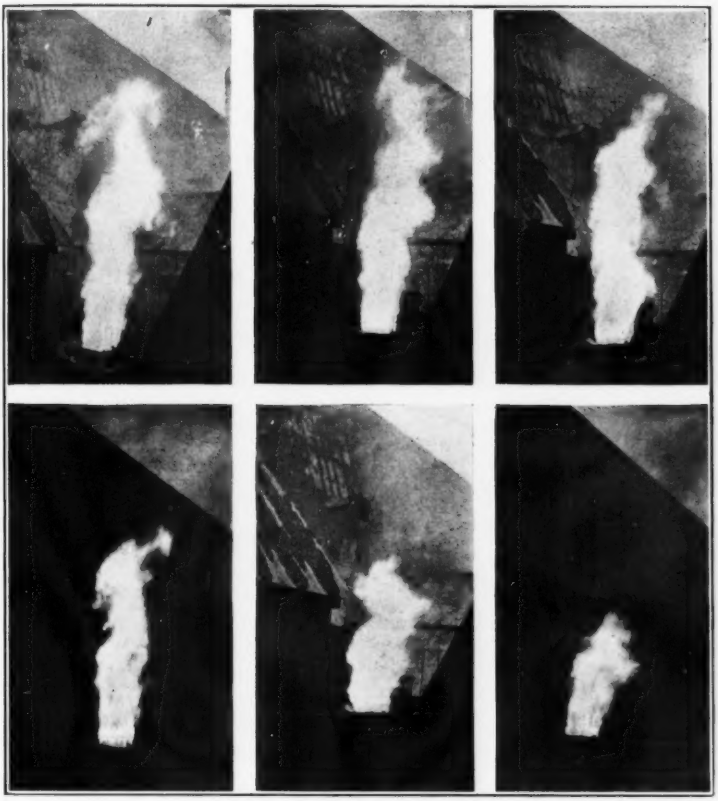


SERIES OF FLAMES DURING A TYPICAL BESSEMER BLOW.

The series runs from left to right, and downward. At the beginning silicon and manganese are being oxidized; the second view is slightly later. In the third, carbon is beginning to burn, with some spitting. The lower row shows the full carbon flame.

pig iron in the basic open-hearth process. Over one-half of the wrought-iron production of the United States is made from wrought-iron scrap by building it up into "piles," heating to a welding heat, and re-rolling into the desired shapes and sizes.

BESSEMER PROCESS.—In the Bessemer process, perhaps 10 tons of melted pig iron is poured into a hollow- pear-shaped converter lined with silicious material (page 51). Through the molten material is then forced 25,000 cubic feet of cold air per minute. In about four minutes the silicon and manganese are all oxidized by the oxygen of the air and have formed a slag. The carbon then begins to oxidize to



SERIES OF BESSEMER FLAMES, CONTINUED.

The flame is beginning to drop, until the end of the blow is reached. The views were taken at vessel No. 1, Edgar Thomson Works, with an 18-ton charge and a blow of about 9½ minutes.

carbon monoxide, CO, and this boils up through the metal and pours out the mouth of the vessel in a long brilliant flame. After another six minutes the flame shortens or "drops"; the operator knows that the carbon has been eliminated to the lowest practicable limit (say 0.04 per cent) and the operation is stopped. So great has been the heat evolved by the oxidation of the three impurities that the temperature is now higher than it was at the start, and we have a white-hot, liquid mass of relatively pure metal. To this is added a carefully calculated amount of carbon to produce the desired degree of strength or hardness or both; also about 1½ per cent of manganese and 0.2

A BESSEMER CONVERTER BLAZING.

per cent of silicon.* The manganese is added to remove from the bath the oxygen with which it has become charged during the operation and which would render the steel unfit for use, and also to neutralize partially the effect of sulphur. The silicon is added to get rid of the gases which are contained in the bath and thus to prevent

* In the case of making rail steel. Only one-half to two-thirds of this silicon and manganese are found in the final steel.

the formation of blowholes. After adding these materials, or "recarburizing" as it is called, the metal is poured into ingots which are allowed to solidify and then rolled, while hot, into the desired size and form. The characteristics of the Bessemer process are: (1), great rapidity of purification, say ten minutes per "heat," (2), no extraneous fuel used; and (3), the metal is not melted in the furnace where the purification takes place.

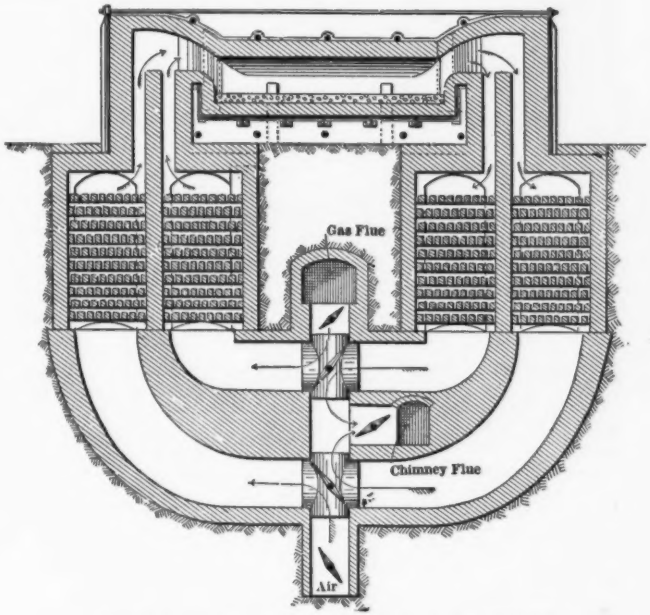
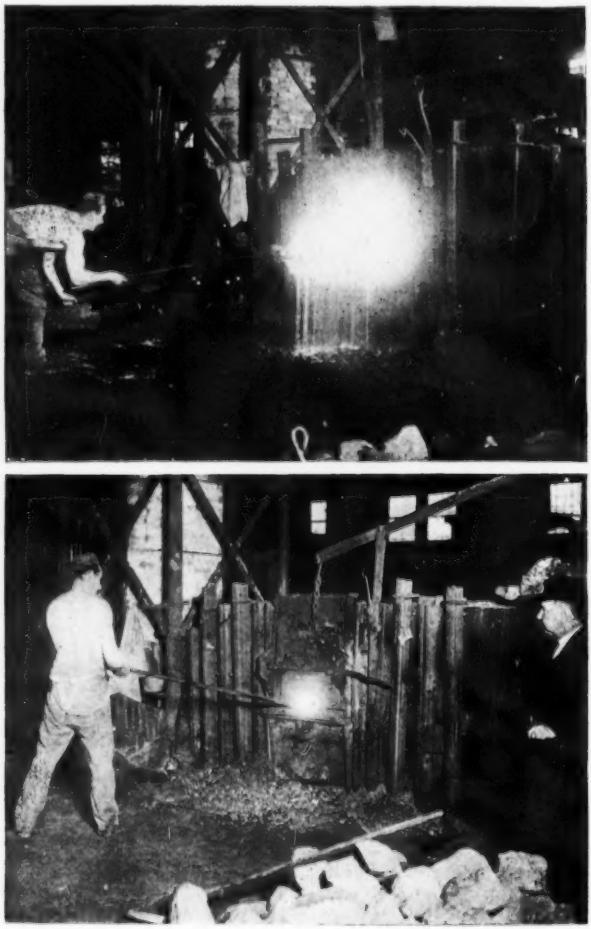


DIAGRAM OF REGENERATIVE OPEN-HEARTH FURNACE.

The four chambers below this furnace are filled with checkerwork of brick with horizontal and vertical channels through which the gas and air may pass. The gas enters the furnace through the inner regenerative chamber on one side and the air enters through the corresponding outer one. They meet and unite, passing through the furnace and thence dividing into proportional parts and passing to the chimney through the two regenerative chambers at the opposite end. In this way the brickwork in the chambers is heated up. The current of gas, air and products of combustion is changed every 20 minutes whereby all four regenerators are always kept hot. The gas and air enter in a highly preheated condition and thus give a greater temperature of combustion, while the products of combustion go out of the chimney at a relatively low heat and thus fuel economy is promoted.

ACID OPEN-HEARTH PROCESS.—The acid open-hearth furnace is heated by burning within it gas and air, each of which has been highly preheated before it enters the combustion chamber. A section of the furnace is shown just above. The metal lies in a shallow pool on



PUDDLING IRON, AND WITHDRAWING THE BALL FROM THE PUDDLING FURNACE.

the long hearth, composed of silicious material, and is heated by radiation from the intense flame. The impurities are oxidized by an excess of oxygen in the furnace gases over that necessary to burn the gas. This oxidizes the slag and then the slag oxidizes the impurities.

This action is so slow, however, that the 3 per cent to 4 per cent of carbon in the pig iron would take a long time for combustion. The operation is therefore hastened in two ways: (1), iron ore is added to the slag to produce the following reaction:—

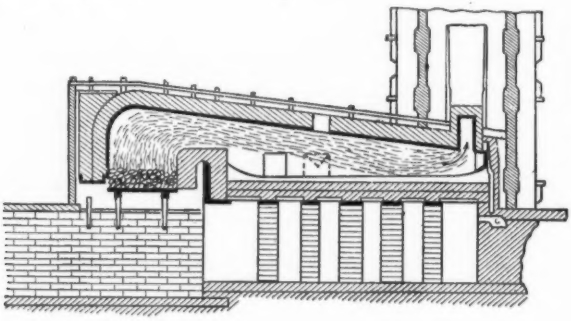
$$Fe_2O_3 + 3C = 3CO + 2Fe;$$

and (2), the carbon is diluted by adding varying amounts of cold steel scrap instead of all pig iron. The steel scrap and ore are added to the charge at the beginning of the process, and it takes about 6 to 10 hours to purify a charge, after which the metal is "recarburized" and cast into ingots. The characteristics of the open-hearth process are: (1), a long time occupied in purification; (2), large charges treated in the furnace (the modern practice is usually 30 to 75 tons to a furnace); (3), at least a part of the charge is melted in the purification furnace; and (4), the furnace is heated with preheated gas and air.

Basic Open-Hearth Process.—The basic open-hearth operation is similar to the acid, with the difference that to the bath is added a sufficient amount of lime to form a very basic slag. This slag will dissolve all the phosphorus that is oxidized, which an acid slag will not do. We can oxidize the phosphorus in any of these processes, but in the acid Bessemer and the acid open-hearth furnaces the highly silicious slag rejects the phosphorus and it is immediately deoxidized again and returns to the iron. The characteristics of the basic open-hearth process are the same as those of the acid open-hearth with the addition of: (5), lime is added to produce a basic slag; (6), the hearth is lined with basic, instead of silicious, material in order that it shall not be eaten away by this slag; and (7), impure iron and scrap may be used, because phosphorus, and (to a limited extent) sulphur can be removed in the operation.

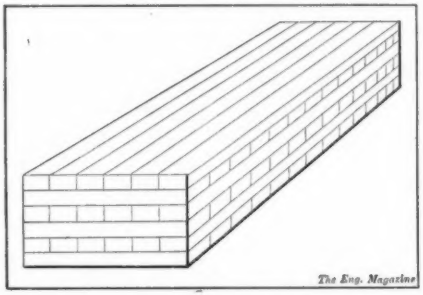
Puddling Process.—Almost all the wrought iron is to-day made by the puddling process, invented by Henry Cort about 1780, with certain valuable improvements by Joseph Hall fifty years later. In this process the pig iron is melted on the hearth of a reverberatory furnace, lined with oxide of iron (page 58). During the melting there is an elimination of silicon, manganese, phosphorus, and sulphur and the formation of a slag, which automatically adjusts itself to a very high content of iron oxide by dissolving it from the lining. After melting the heat is reduced and a reaction set up between the iron oxide of the slag and the silicon, manganese, carbon, phosphorus, and sulphur of the bath, whereby the impurities are oxidized and all removed to a greater or less extent. The slag, because of its basicity (by iron oxide), will retain all the phosphorus oxidized, and therefore the greater part of this element is removed. The oxidation of all the

impurities is produced chiefly by the iron oxide in the slag and the lining of the furnace, although it is probable that excess oxygen in the furnace gases assists, the slag acting as a carrier of oxygen from it to the impurities.



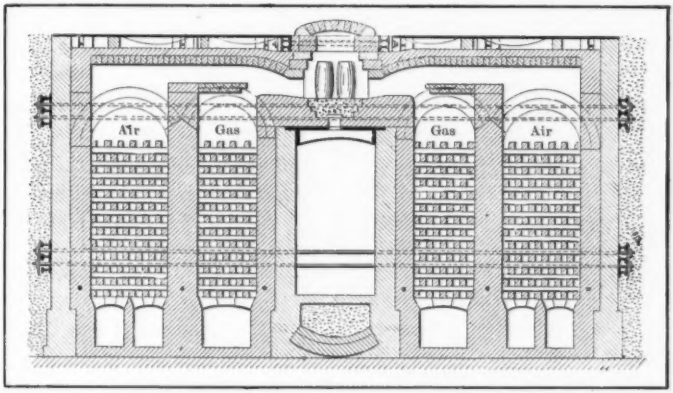
SECTIONAL VIEW OF PUDDLING FURNACE.

The purification finally reaches that stage at which the utmost heat of the furnace is not sufficient to keep the charge molten, because iron like almost every other metal melts at a higher temperature the purer it is. The metal therefore "comes to nature" as it is called; that is to say, it assumes a pasty state. The iron is then rolled up into several balls, weighing 125 to 180 pounds apiece (page 56), which are removed from the furnace dripping with slag and carried over to an apparatus in which they are squeezed into a much smaller size and a large amount of slag separated from them. The squeezed ball is then rolled between grooved rolls to a bar, whereby the slag is still further reduced so that the bar contains at the end usually about 1 per cent or 2 per cent. This puddled bar, or "muck bar," is cut into strips and piled up, as shown just below, into a bundle of bars which are bound together by wire, raised to a welding heat, and again rolled into a smaller size. This rolled material is then known as "merchant bar" and all wrought iron, except that which is to be used for manufacture into crucible steel, is treated in this way before sale. The effect of the further



METHOD OF PILING MUCK BAR.

rolling is to eject more slag and also to make a cross network of fibres, instead of a line of fibres all running in the same direction, *i.e.*, lengthwise of the bar. The fibres are produced by the action in rolling or drawing out the slag into strings and also producing long fibres of metal, each of which is surrounded by an envelope of slag.



REGENERATIVE GAS CRUCIBLE-STEEL MELTING FURNACE.

CRUCIBLE PROCESS.—Wrought iron is converted into steel by the operation of carburizing, or adding carbon to it. This is today accomplished in two ways: (1), by the cementation or steel conversion process, in which carbon is allowed to soak into red-hot iron in a manner like in nature to the absorption of ink by blotting paper; and (2), by the crucible process in which wrought iron is melted in a crucible with carbon, or with iron containing carbon, *e.g.*, cast iron. The cementation process, on account of the length of time required and the very large amount of fuel used, has now been largely superseded by the crucible process, in which the wrought iron is cut up into small pieces and melted in covered crucibles, the desired amount of carbon being placed on top of the charge before the melting, together with any other alloying element desired, such as chromium, tungsten, manganese, etc. In Sheffield, England, the capital of the crucible-steel industry of the world, coke furnaces, or "melting holes," containing each two crucibles, are almost universally used; while in America regenerative gas furnaces containing each six crucibles are the common type. In the gas furnace it is necessary that the gas and air for combustion shall be preheated in order that we may obtain fuel economy and also reach the desired temperature for melting quickly. For this preheating the regenerative principle is used.

The characteristics of the crucible process are: (1), wrought iron is the raw material, not pig iron; (2), small units and hand labor are used; (3), labor and fuel costs are very high; and (4), during the operation the material is contained in entirely closed vessels.

COMPARISON OF PURIFICATION PROCESSES.

ACID WITH BASIC OPEN-HEARTH.—Acid open-hearth steel is believed by engineers to be better than basic, and is usually specified in all important parts of structures—although not so rigidly today as a few years ago. This is in spite of the fact that phosphorus and sulphur, two very harmful elements, are lower in the basic steel. The basic process is much less expensive than the acid, because high-phosphorus pig iron and scrap are cheap, the lower cost of materials used more than balancing the greater cost of the basic lining and the lime additions, and because also the acid furnace has a higher output, since the heats are shorter.

The reasons for the preference of acid steel are as follows: (1), a basic slag will dissolve silicon from the metal; we therefore recarburize in the basic process by adding the recarburizer to the steel after it has left the furnace, instead of in the furnace, as we do in the acid process. Should any basic slag be carried over with the metal, however, which is liable to happen, there is the danger that the ingots will be too low in silicon. They are then impregnated with gas bubbles, or "blow holes;" (2), moreover the recarburizer does not mix with the steel as well if it is not added in the furnace and this sometimes produce irregularities; (3), a basic slag is usually more highly oxidized than an acid one. Therefore the metal at the end of the operation is more highly charged with oxygen. For this reason we add a larger amount of manganese in the recarburizer, but the remedy is never quite as good as prevention; (4), since we cannot remove the phosphorus from the bath in the acid process, it is necessary to use only picked iron and scrap, whereas, in the basic process, good steel can be made from almost any quality of material. Many engineers believe, however, that a better grade of steel results from using the picked material; (5), it occasionally happens in the basic process that, after the phosphorus has all been oxidized in the slag and the operation is ended, some of it will get back into the metal again. This is especially liable to happen when basic slag is carried over into the ladle upon tapping the furnace. If this occurs, and if the bath is very hot, a reaction may take place between the basic slag and the acid lining of the ladle whereby the slag will be enriched in silica and phosphorus will be forced out of it.

BASIC OPEN-HEARTH WITH BESSEMER.—Basic open-hearth steel

is better than Bessemer steel. The reasons for this are believed to be: (1), the open-hearth process being slower, more attention and care can be given to each detail. This is particularly true of the ending of the process, for if the Bessemer process is continued only a second or so too long, the bath is highly charged with oxygen, to its detriment, and even under normal circumstances there is more oxygen in the metal at the end of the Bessemer process than at the end of the basic open-hearth, because there has been so intimate a mixture between metal and air; (2), for the same reason the Bessemer metal is believed to contain more nitrogen and hydrogen* which are thought to be deleterious; (3), the heat of the Bessemer process is dependent upon the impurities in the pig iron, and especially upon the amount of the silicon, and can be controlled only to a limited extent by methods that are not perfect in their operation. Furthermore, the heat is regulated according to the judgment of the operator and his skill in estimating the temperature of the flame. Irregularities therefore result at times and these produce an effect on the steel, because the temperature at which the ingots are cast should be neither too high nor too low. It is true that the temperature of the open-hearth steel is also regulated by the judgment of the operator, but more time is afforded for exercising this judgment and the heat of the operation is more easily controlled; (4), in the Bessemer process we must get rid of all the carbon first and then recarburize to the desired point. In the open-hearth process we may stop the operation at any desired amount of carbon and then recarburize only a small amount. Therefore the open-hearth has the advantage of greater homogeneity when making high-carbon steel, since a large amount of recarburizer may not distribute itself uniformly. In order to produce the best quality of steel it must be cast into ingot molds within a certain limited range of temperature which varies according to the amount of carbon, etc., that it contains. Therefore in casting the very large heats of the open-hearth process, the ingots must either be very large or else the first one will be too hot and the last one too cold for the best results. If the ingots are large, on the other hand, segregation is liable to be excessive. The large heats of the open-hearth process are therefore disadvantageous to the quality of the steel.

For nearly fifteen years the Bessemer process has been fighting a losing battle to maintain its supremacy against the inroads of the basic open-hearth, which have been possible because of the increasing cost of Bessemer pig iron, due to the exhaustion of the low-phosphorus ores. The pig iron for the Bessemer process must contain

* From moisture in the blast.

so little phosphorus that, after allowing 10 per cent loss of metal during the blow, the phosphorus in the steel shall be not over 0.100 per cent. Ores low enough in phosphorus to make this grade of metal have, therefore, come to be known as "Bessemer ores." The requirement of such an ore is that the percentage of iron in it must be at least 1,000 times the percentage of phosphorus. During the year 1906, the Bessemer process in the United States yielded very much to the basic open-hearth and it would seem as if there was no chance of its ever taking so important a position again unless new iron ores low in phosphorus are discovered.

On account of its ability to make low-carbon steel more readily than the basic open-hearth, the Bessemer process has a firm hold on the wire and welded steel pipe industry, although even here the open-hearth process has encroached. For rolling very thin for tin plate, etc, we want a metal relatively high in phosphorus, and therefore the Bessemer process is largely used here, although in some cases ferro-phosphorus is being added to basic open-hearth metal to accomplish the same result. The reason low phosphorus is desired is because the plates are rolled very thin by doubling them up and putting several thicknesses through the rolls at the same time. Low-phosphorus metal welds together too much under these circumstances.

The chief requisites of railroad rails are lack of brittleness and ability to withstand wear. The Bessemer process is able to provide such a material, and it works so well in conjunction with the rapid, continuous operation of the rail-rolling mill that it has a decided advantage. It produces a small tonnage of ingots at frequent intervals (say 15 tons every 7 minutes), while the open-hearth process provides a large tonnage of ingots, which may come at irregular intervals and thus alternately delay and over-crowd the rail-mill operations. But notwithstanding these advantages, an increasing tonnage of basic open-hearth rails is made every year in the United States. Lately this has attracted widespread interest, owing to reports of an alarming number of rail breakages and the action of some railroads in blaming the Bessemer process therefor. It is true that every year there becomes a greater scarcity of Bessemer ores, and therefore an increasing amount of phosphorus in the steel, so that it is no secret that many rails have been made within the past year containing more than the allowable 0.100 per cent phosphorus. Phosphorus makes the steel brittle, especially under shock and in cold weather. It also makes the steel hard to resist wear, but this hardness is better obtained by means of carbon, and low-phosphorus, high-carbon steel rails would undoubtedly break less in the track. It is to be remembered that heavier

trains are being run every year, and this brings greater strains upon the rails in comparison with which they have not been correspondingly increased in size. At the present time so very large an amount of capital is tied up in Bessemer rail mills, and it would take so long to change them over into open-hearth mills, that there is no immediate prospect of a great replacement. The acid and Bessemer steel production of the principal countries of the world is shown in Tables II and III, while the recent history of open-hearth steel-rail manufacture is shown briefly in Table IV.

TABLE II. STEEL PRODUCTION OF PRINCIPAL COUNTRIES. 1906.

	United States.	Germany.	Great Britain.
Acid Converter	12,275,253	407,688	1,307,149
Basic Converter	.....	6,772,804	600,189
Total Converter	12,275,253	7,180,492	1,907,338
Acid Open-hearth	1,321,613	230,668	3,378,691
Basic Open-hearth	9,649,385	3,534,612	1,176,245
Total Open-hearth	10,970,998	3,765,280	4,554,936
Crucible and Special	118,500	189,313	....?....
Total	23,364,751	11,135,085	6,462,274
Proportion Steel to Pig Iron.	92.3	89.2	....

TABLE III. MAKE OF ACID AND BASIC STEEL. 1906.

	Acid.		Basic.	
	Tons.	Per Cent.	Tons.	Per Cent.
United States	13,715,366	58.7	9,649,385	41.3
Germany	715,952	6.4	10,419,133	93.6
Great Britain	4,685,840	72.5	1,776,434	27.5
Total	19,117,158	46.7	21,844,952	53.3

TABLE IV. AMERICAN RAILROAD-RAIL MANUFACTURE.

	Gross Tons.			
	Bessemer.*	Open Hearth.†	Wrought Iron.‡	Total.
1900	2,383,654	1,333	695	2,385,682
1901	2,870,816	2,093	1,730	2,874,639
1902	2,935,392	6,029	6,512	2,947,933
1903	2,946,756	45,054	667	2,992,477
1904	2,137,957	145,883	871	2,284,711
1905	3,188,675	183,264	318	3,372,257
1906	3,705,642	.....	...	.....

CRUCIBLE STEEL WITH OTHERS.—Crucible steel is the most expensive of all, costing at least three times as much as the next in price —acid open-hearth steel. It is also the best quality of steel manufactured, and for very severe service, such as the points and edges of cutting tools, the highest grades of springs, armor-piercing projec-

* The first Bessemer rails were made commercially in 1867.

† The first open-hearth rails were made in 1878. In 1881, 22,515 gross tons of open-hearth rails were produced.

‡ The maximum production of iron rails was 808,866 gross tons in 1872.

tiles, etc., it should always be employed. The reason for its superiority is believed to be that it is manufactured in a vessel which excludes the air and furnace gases, and therefore is freer from oxygen, hydrogen, and nitrogen. Perhaps the fact that the process is in some ways under a little better control than any of the others, and the metal receives more care, on account of being manufactured in small units, assists in raising the grade. Crucible steels are usually higher in carbon than Bessemer and open-hearth steels, because the special service to which the crucible steels are adapted is usually one requiring steel that can be hardened and tempered—for example, cutting tools, springs, etc., and only the high-carbon steels are capable of this hardening and tempering.

Wrought Iron with Low-Carbon Steel.—Wrought iron costs 10 per cent to 20 per cent more than the cheapest steel. Its claims to superiority over dead-soft steel consist in its purity and the presence in it of slag. Just how much advantage the slag is, has never been proven; it gives the metal a fibrous structure which, perhaps, increases its toughness and its resistance to breaking under bending, or under a sudden blow, or shock. Some think that the slag also assists in the welding of the material, but this is doubtful and it is probable that the easy weldability of wrought iron is due alone to its being low in carbon. Some also believe that the slag assists the metal in resisting corrosion; hence one reason for the preference of engineers for wrought-iron pipe for boilers and other purposes. There are other qualities of wrought iron which may tend to make it corrode less than steel, chief among which are the absence of blowholes and possibly the absence of manganese, and the presence of phosphorus. It is now believed by many that manganese starts an electrolytic action which hastens corrosion. An advantage of wrought iron in this connection is its rough surface to which paint or other protective coatings will adhere more firmly than to the comparatively smooth surface of steel. Nevertheless the evidence goes to show that *properly made steel* corrodes very little more than wrought iron, especially in boilers, pipe, and other articles which cannot be coated.

The properties of wrought iron are the nearest to those of pure iron of any commercial material, notwithstanding its slag, which because it is mechanically mingled with the metal does not interfere with its chemical or physical behavior. Therefore wrought iron is greatly preferred for electrical-conductivity purposes, and as a metal with high magnetic power for use as armatures of electro-magnets, etc. The advantages I have mentioned—the conservatism of engineers and the capital previously invested in puddling furnaces—are the chief

factors in keeping alive the manufacture of wrought iron. It was freely predicted that the invention of the Bessemer and open-hearth processes would bring about the extinction of the puddling process, but these prophecies have never been fulfilled, although the importance of wrought iron has waned very greatly in fifty years. When under strain greater than it can withstand wrought iron stretches more uniformly over its entire length than steel, as shown thus:

TABLE V.

	Elastic Limit. Lb. per Sq. In.	Ultimate Strength. Lb. per Sq. In.	Elongation, Per Cent. In 12 In.	Elongation, Per Cent. In 18 Ft.	Reduction of Area. Per Cent.
Wrought Iron ...	31,550	48,810	23	15.22	28.30
Steel	33,150	59,260	39	14.40	51.50

This makes wrought iron a much more valuable material for boilers, for example.

SUMMARY.—In order of expense and of quality the different steels are arranged as follows: (1), Crucible; (2), Acid open-hearth; (3), Basic open-hearth; (4), Bessemer. The amounts of the different kinds made today and ten years ago are shown in Table VI. Though I have not made a direct comparison between certain of the classes, *e.g.*, acid open-hearth with Bessemer, their relations may be easily learned by collating the other comparisons given.

TABLE VI.

	Bessemer.		Open-Hearth.				Crucible, etc.	
1906..	12,275,253	52%	9,649,385	41%	1,321,613	6%	118,500	1%
1896..	4,909,128	78%	776,256	12%	522,444	9%	68,524	1%

Many engineers will be interested in the uses to which the annual steel and wrought iron production of the United States is put, which are shown below:

TABLE VII. USES OF STEEL AND WROUGHT IRON.
Gross Tons. 1905.

	Steel.	Wrought Iron.
Railroad rails	3,375,611	318
Railroad splice bars	179,900	17,422
Structural shapes	1,648,889	11,630
Merchant bars *	2,271,162	1,322,439
Rods for wire, and wire products	1,307,407	1,281
Rods for wire nails	500,000	.....
Plate for cut nails	40,483	24,059
Plates †	2,031,184	10,022
Sheets †	1,428,890	62,134
Skelp ‡	983,198	452,797
Hoops, bands and cotton ties	442,664	2,863
Spike and chain rods, horseshoe bars, strips, etc.	529,288	154,620
Blooms and billets	41,349	405
Castings	560,767	.....

* Merchant bars are bars of small sizes which are usually sold to be worked up into other forms.

† Plates are gauge No. 12 and thicker; sheets are gauge No. 13 and thinner.

‡ Skelp is flat strips which are welded into pipe.

DISTINGUISHING BETWEEN THE DIFFERENT PRODUCTS.

Low-carbon steel pipe, merchant bars, horse-shoe blanks, etc., sometimes masquerade under the name of wrought-iron; high-carbon open-hearth and Bessemer-steel merchant bars, tool blanks, etc, sometimes masquerade as "crucible steel," or perhaps, "cast steel," which is the trade name for crucible steel. Other deceptions are not unknown; indeed, even malleable cast iron is sold oftentimes as "steel castings." It is therefore important for engineers to understand the essential differences between these materials, although care in the wording of contracts and specifications should be the important consideration and should precede watchfulness over the products. The definitions of iron and steel materials are in such a confused and unsettled condition that it does not do to rely upon them at all, especially where a law suit may be involved, and contracts in clear, simple language, free from legal and metallurgical phraseology, are the best safeguards. But even where it is entirely plain what material is called for there is always a temptation to substitute steel for wrought iron, Bessemer for open-hearth, basic for acid, and Bessemer or open-hearth for crucible steel. In case any such substitution is suspected there are means by which the material may be tested, aside from its strength and ductility which may or may not be in the contract. The tests are somewhat delicate and usually require the judgment and experience of an expert and one who has standard samples of the different grades of material for comparison, because the details of manufacture vary from district to district, and still more so depending upon the purpose for which the products are to be used.

Wrought iron may be distinguished from low-carbon steel by the fact that it contains slag. Usually there is more than 1 per cent. of slag in iron and less than 0.20 per cent. slag (including metallic oxides) in steel. The slag may be determined either by chemical or microscopical analysis. Normal wrought iron is practically free from manganese, while normal Bessemer and open-hearth steel will contain 0.50 per cent. or more. Wrought iron generally contains more than 0.100 per cent. phosphorus, while good steel should never do so.

Crucible steel normally has less than 0.40 per cent. manganese and more than 0.20 per cent. silocon, while open-hearth and Bessemer steels normally have more than 0.50 per cent manganese and less than 0.20 per cent silicon. In the case of steel castings, however, this rule for silicon does not apply, as Bessemer and open-hearth steel castings are sometimes as high as 0.60 per cent. silicon. It is possible to make both Bessemer and open-hearth steels low in manganese, but they cannot be made low in both manganese and silicon without great

danger from blowholes, while the difficulty is not met with to the same extent in crucible steel. When crucible steel is ordered low in carbon there is a much greater temptation to substitute another steel for it.

Acid open-hearth steel may be distinguished from basic open-hearth steel because it will normally be higher in silicon, and usually in phosphorus also, and lower in manganese. The same differences exist between acid and basic Bessemer steel.

Basic open-hearth steel may be distinguished from Bessemer steel by its lower manganese, silicon, phosphorus, and (generally) sulphur, as well as by the fact that it dissolves much more slowly in dilute hydrochloric acid.

It is possible to place such physical specifications in a contract as practically to insure obtaining the grade of material ordered. For example, such a high degree of ductility may be demanded, especially the percentage elongation in 10 or 20 feet, that nothing but wrought iron will give it; the strength and ductility may be put so high as to make it too dangerous to try to supply anything but crucible steel for the order; or they may be put a little lower so as to practically exclude Bessemer steel. The average physical differences between acid and basic open-hearth steel are not great enough to make this method of assurance so practicable, but it is again possible in the case of basic and acid Bessemer steel in England, where alone both these kinds of steel are made in important quantities.

POURING CRUCIBLE STEEL.

ASBESTOS; ITS MINING, PREPARATION, MARKETS, AND USES.

By E. Schaaf-Regelman.

ASBESTOS derives its name from the Greek, the term signifying "incombustible," "inconsumable," and while we can trace nearly to the dawn of history, the knowledge of the existence and application of this peculiar "stone for spinning purposes," it is but a decade or two since we have had a real and important asbestos industry. During the last four to six years this mineral has been applied to so many new uses that it is safe to say that asbestos goods are indispensable today for a great number of industrial purposes, and the recent unprecedented rise in prices has attracted attention so widespread that a more intimate knowledge of the conditions actually governing the industry should be beneficial to many.

The mineral asbestos, chiefly a silicate of magnesia, but containing also lime, iron, alumina, and water, is fibrous in structure, and in color varies from snowy white to green, blue, yellow, pink, and brownish hues. The mineralogist distinguishes two chief varieties, the chrysotile and amphibole asbestos, the principal difference in composition, aside from a slightly varying percentage of the above-named ingredients, being the amount and condition of the water present. Amphibole asbestos contains about 5 per cent of water, all of which is "combined," while chrysotile contains in the average about 15 per cent of water, of which only 12 to 13 per cent are chemically bound to the other constituents, while about 2 to 3 per cent are free or hygroscopic. For this reason chrysotile asbestos loses its strength, when heated, at about 660 degrees C., while amphibole asbestos can easily stand a temperature twice as high without disintegrating; from a purely technical point of view, therefore, the latter variety is a better material for protection against fire than chrysotile asbestos; but all deposits of amphibole asbestos known to this day exhibit a very brittle fibre, which cannot be used for spinning or weaving; its application is therefore limited, and this variety is unimportant from a commercial standpoint, while the chrysotile asbestos, occurring in much greater abundance in nature, has much stronger

BELL ASBESTOS MINES, THETFORD, P. Q. MAIN PIT.

fibres of great flexibility and sufficient tensile strength; qualities which give it great economic importance.

The historians of old Greek and Roman culture have mentioned repeatedly that the corpses of their kings and heroes, when prepared for cremation were wrapped in incombustible blankets in order to separate their ashes from those of the funeral pile, and Pausanias states that the wick of the eternal lamp in the temple of Pallas Athene in Athens was made of "crystallic flax." Charlemagne amused and astonished his guests by having a table cloth, made from "cotton stone," cleaned after a meal by throwing it into the fire and taking it out again unburnt and uninjured.

However, the practical use of asbestos was for a long time of a sporadic nature only, and the first experiments for using it on something like a commercial scale were made in the Alps in the early seventies; at about the same time the first specimens of a very fine asbestos from Canada, with silk-like fibres, were exhibited in London, but it was not until 1878 that mining operations of a tentative character were commenced in the Dominion. A lot of about 50 tons of selected crude asbestos was shipped to England, but great difficulty was experienced in marketing it, as no regular demand for asbestos was established as yet; the uncertainty of the supply, as well as the high prices due to very crude mining methods conducted on a small scale, were responsible for this lack of interest.

BELL ASBESTOS MINES. SHOWING THE CHARACTER OF THE SERPENTINE ROCK, AND THE METHOD OF HOISTING BY CABLEWAYS.

The good quality of the Canadian asbestos and the ease with which it can be spun and woven, however, attracted sufficient attention to induce some enterprising English and American capitalists to investigate the deposits further, and as these investigations revealed very encouraging features, busy mining camps soon sprang up around Black Lake and Thetford in the Canadian province of Quebec, and a steady betterment of the mines as well as an ever-increasing demand for their products rewarded those who had ventured to create the new industry. While the scope of operations increased steadily from that time on, the methods of mining remained rather primitive, and little or no machinery was used to replace hand labor until in the nineties adverse industrial conditions in general caused a depreciation in values, and it became obvious that cheaper production was necessary to leave the producers an adequate profit, inasmuch as other countries, especially Italy and Russia, had also, in the meanwhile, begun the exploitation of their asbestos deposits and had brought them to a productive basis. In the middle of the nineties the Canadian asbestos industry therefore experienced a crisis; many of the smaller mines, and those producing but a limited amount of the better grades, had to close down, and the adoption of cheaper working methods and a better saving of values became imperative. The treatment of

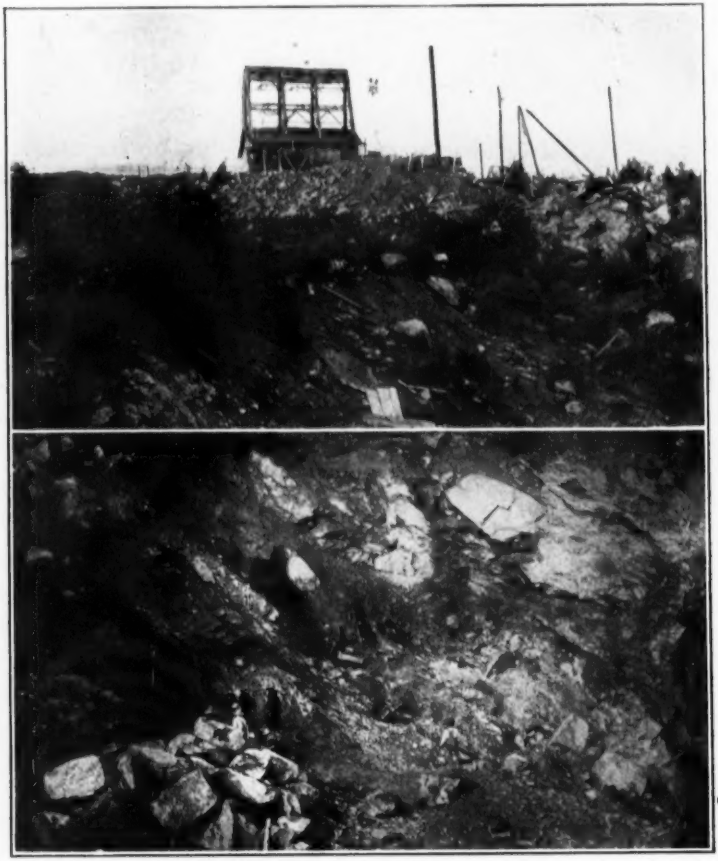
the asbestos rock, requiring devices entirely different from those used in other concentrating or milling plants, demanded the construction of special machinery and (as Mr. Fritz Cirkel says, in speaking of this period in his monograph on "Asbestos, its Occurrence, Exploitation and Uses," one of the best and most exhaustive treatises on the subject): "The asbestos industry is a striking example of what human ingenuity, if applied in the right direction, may accomplish. It demonstrates that in order to attain success it is necessary to strive, to seek to find, and not to yield." Many a set of experimental machinery was installed, discarded, and remodeled, before satisfactory results were reached. The difficulties to be overcome and the problems to be solved were manifold, as the aim was not only to replace hand labor by mechanical treatment, wherever possible, but also to liberate the asbestos from the adhering rock better than had hitherto been possible. Furthermore, it was necessary to turn the short-fibre material, large quantities of which were then lying on the waste dumps, into a marketable product, thus prolonging the life of a mine considerably; nothing but mechanical treatment could accomplish this.

It would lead too far to describe all the separate phases of evolution in this industry; be it sufficient therefore to say that there are more than a dozen plants in successful operation now with complete drying, milling, screening, fiberizing, and classifying devices, and while no two plants are exactly alike, the general principles fol-

CRUDE ASBESTOS, BEAVER ASBESTOS COMPANY'S MINES.

lowed are almost the same in all of them and may be shortly described as follows:

The first step towards the production of a marketable asbestos is, of course, the mining of the asbestos-bearing rock, and this is done in quarry fashion in rather large open pits; the methods of working in them have experienced the well-known and identical changes which mining in general has undergone during the last two decades. Leaving the peculiarities of some of the mines out of consideration, it can be said that in most of them the broken rock is cobbed and assorted into the so-called crude asbestos, i. e., one with a fibre length of at least



MAIN PIT, BROUGHTON ASBESTOS FIBRE COMPANY, SHOWING FLOOR AND HOISTING PLANT ON THE RIM.

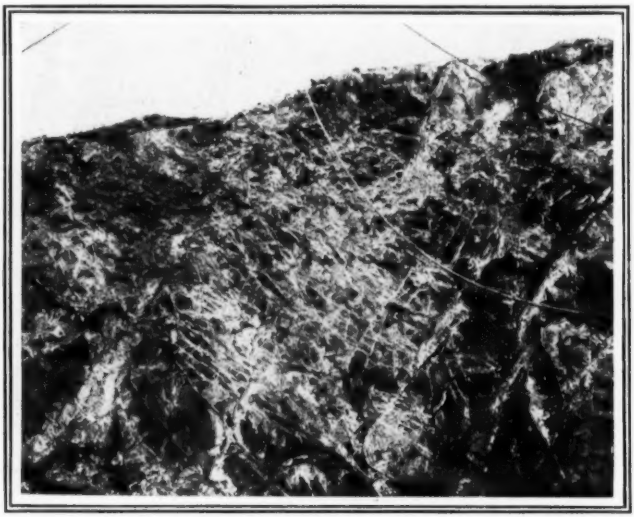
$\frac{3}{8}$ inch, and into rock with shorter fibre, which is treated in the mill. The crude asbestos is then transported into cobbing sheds and by hammering and screening is further liberated from adhering rock and classified into two qualities, No. 1 crude measuring at least $\frac{3}{4}$ inch in length of fibre, and No. 2 crude the smaller sizes. This classification is done by rule-of-thumb methods, and considering the fact that it is nearly impossible to free the crude asbestos entirely from the rock, some stony matter adhering firmly to the end of a vein if the crude asbestos is in lumps, it can easily be seen that even the quality of

ENTRANCE TO TUNNEL, BELL ASBESTOS MINES. THE FIRST SUCCESSFUL ATTEMPT TO MINE ASBESTOS BY UNDERGROUND WORKINGS.

these standard grades is apt to vary and depends to a great degree upon the supervision over the laborers doing the cobbing, especially as this is done for the greater part by contract work. This method of preparing the crude asbestos for the market has not changed at all and it is not likely that mechanical treatment can be substituted.

All the rock mined, as well as the tailings from the cobbing sheds, goes to the fiberizing plant for further treatment and, as the material

contains much moisture, it must be dried first. This is done mostly in rotary dryers, heated by fire from the outside, but in some cases the drying is effected by spreading the material on a system of steam pipes supplied with exhaust steam; while this latter method is economical, much floor space is required for a large drying capacity. Before it is possible to liberate the fibre from the rock, the latter has to pass through jaw crushers; it is then further reduced in rotating crushers, and after having thereafter passed through rolls, the most



ASBESTOS QUARRY OF STANDARD MINE, BLACK LAKE. SHOWING THE ASBESTOS VEINS RUNNING IN ALL DIRECTIONS.

important part of the work begins—that which it has been most difficult to accomplish—namely, the fiberizing proper, and the complete separation of the asbestos fibres from rock particles. This is now done by beaters and by cyclones, the first named consisting chiefly of a large cylindrical trommel of boiler plates, in which strong cutting knives, attached to a quickly rotating center axle, desintegrate the material and (the whole apparatus being inclined) make it travel from the feed hole to the discharge. Cyclones did not give much satisfaction during the early period of their application, but now they have been perfected and no mill would be complete without them today. They consist essentially of two beaters, shaped like screw propellers, running in opposite directions and making as many as 2,500 revolutions per minute. They are encased in a cast-iron chamber, and all material reduced to about the size of a hazel nut and

smaller is taken off by air suction and falls onto a shaking screen, whence the liberated fibre is removed by an exhaust fan, and the stony matter is shaken through; this is either further reduced in size and treated again in the same manner, or milled to an impalpable powder and used for plaster, cement, and similar purposes. The fiberized asbestos taken up from the screens by air suction is blown into settling chambers and must now be graded, this being done chiefly in rotating screens. In most cases the fibre passes over series of rotating and shaking screens and endless conveyors—so called picking belts—and from them the longer fibre, hidden in the rock and suitable for crude asbestos, can be taken up by hand; or barren rock can be picked out by hand to relieve the subsequent operations from useless material. The residue from the screens is either re-ground and re-fiberized or finely powdered according to size and character, while the fibre is always removed by air suction.

In no other country has the mining of asbestos, and especially its preparation for the market, attained such proportions as in Canada, and the excellent quality of the Canadian asbestos, the careful and clean separation of the fibre, and the comparative richness and accessibility of the deposits, will enable Canada to hold the lead in the production of asbestos for a great number of years to come. While the total production of all grades of asbestos in Canada has probably exceeded 75,000 tons during the last year, with prices ranging from $300 per ton for the best grade of crude down to $10 per ton for the shortest fibre, the United States has produced but 3,500 tons (approximately), very little of which is chrysotile asbestos, and the amphibole, as pointed out before, is of a much cheaper grade, giving the American asbestos an average value of about $15 per ton.

Of other producing countries the most important is Russia, whose output during the last year has probably exceeded 3,000 tons of good grade material, all suitable for spinning purposes, but no statistical figures are available for the production of inferior grades. The Russian fibre is not nearly as silky as the Canadian; it is harsher and of a yellowish to brownish hue. The chief drawbacks in Russia are the remoteness of the deposits from the consuming centres in Europe, and the shortness of the season, lasting in the average scarcely two months. As no machinery or mechanical means are employed, the work must be rushed feverishly to attain this comparatively large output in so short a time, and the largest mine is said to employ about 5,000 men when in full operation.

The first country in which asbestos was produced is Italy, and while the chemical composition of the Italian asbestos is practically

MILL AND FIBERIZING PLANT, BEAVER ASBESTOS COMPANY, THETFORD, P. Q.

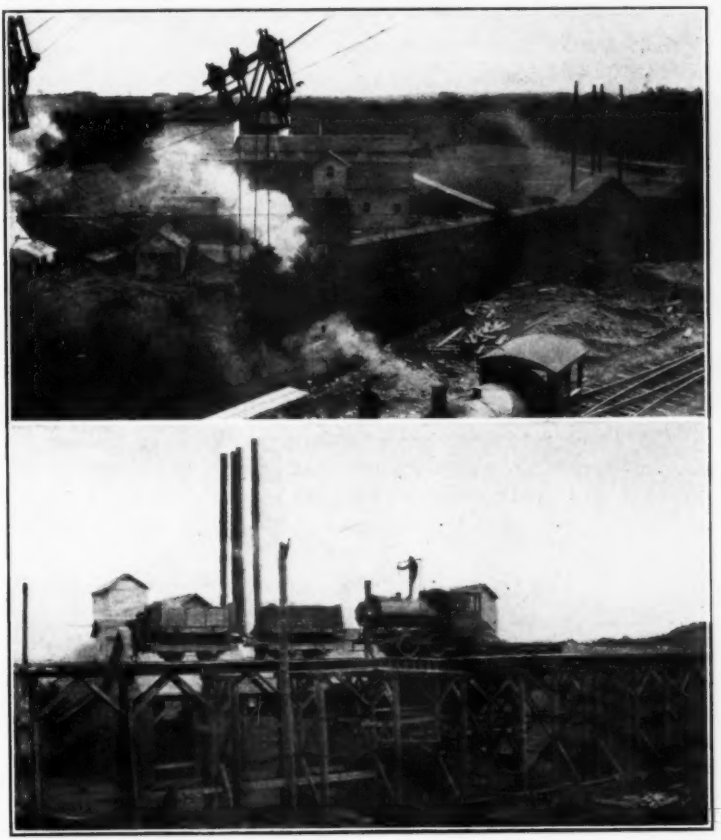
the same as that of the Canadian product, its physical properties are quite different, and the asbestos fibres from the three principal Italian localities differ one from another; their common characteristics, however, are a grayish to brownish color, a touch somewhat similar to that of soapstone, and a comparative rarity of good, long fibre, the occurrence of which is pockety. The high altitudes at which workable asbestos deposits are found, the nature of the rock making mining by hand imperative, and the ever existing danger from landslides, have greatly hampered the development of this industry and made it but little remunerative, though the extent of asbestos-bearing ground seems practically unlimited.

A very promising country seems to be South Africa, and great attention has been paid of late to the asbestos shipped from there to various European countries. The African fibre has most of the good qualities required; it is long, soft, pliable, but harsher than the best Canadian; it can be separated most easily from the rock and its specific gravity is lighter than that of any other asbestos. Its most salient feature is the beautiful blue color, ranging from lavender to marine blue; even the finest fibre retains this color, while most of the other varieties of asbestos, being greenish, gray, or yellow when in masses, look white when fiberized. This blue color is due to a large proportion of protoxide of iron present, which averages 30 to 35 per cent and makes the blue asbestos less desirable for electrical insulations.

Asbestos has also been discovered in other countries, and New-

foundland, New Zealand, Queensland, and South Australia seem to possess workable asbestos deposits, but so far they are undeveloped and no quantities of commercial importance have been shipped. The newest discovery is that of a pink-colored asbestos in India, which looks very pretty, but, being of the amphibole variety, the low value forbids shipping to European or American markets and it is therefore of scarcely more than mineralogical interest.

As mentioned before, the uses of asbestos have increased enormously of late and it would require a special treatise to cover this phase of the subject. The application of asbestos in its various forms



BROUGHTON ASBESTOS FIBRE COMPANY'S PLANT, SHOWING FIBERIZING PLANT, TRESTLE FROM WHICH ASBESTOS ROCK IS FED TO THE MILL, AND CONVEYING CABLEWAY.

varies greatly in different countries, but if one be called upon to make a general distinction between American and European practise, it can be said that America uses the shorter fibres in the manufacture of pipe and boiler coverings, as well as for plaster, cement, etc., in proportionately much larger quantities than European countries, while the latter use more crude asbestos and the longest grades of fiberized asbestos for spinning, weaving, and braiding, and the long and medium fibres for the manufacture of insulating materials with admixtures of kieselguhr (infusorial earth), ground cork, felt, or magnesia, or for stuffing and packing purposes as a rubber-asbestos-combination.

The spinning and weaving of asbestos has offered many difficulties, as the asbestos fibres have no rough surface like wool or cotton, but are very smooth and thus have a tendency to slip by one another, when twisted and subject to tension. An admixture of vegetable or animal fibre was therefore often necessary, but while these facilitated the manufacturing operations, they impaired the fire resistance of the fabric, and special machinery and ingenious devices had to be invented to enable the successful spinning of a pure asbestos yarn; it is, however, now possible to make a single asbestos thread which, though weighing no more than one ounce per hundred yards, has a fair strength, and braided material can be made much more resistant to torsion and tension; while asbestos ropes, chiefly used by the fire department, can be strengthened either by interwoven wires or by having a wire-rope core. The use of asbestos for theatre curtains, fireman's and electrician's gloves and garments, partition walls, and for the isolation and insulation of certain parts of buildings or steamers from other parts, are well-known, and large quantities of asbestos are annually used for these purposes. The packing and insulation of steam pipes, boilers, refrigerators, etc., has assumed large proportions in America, especially in the form of magnesia sectional coverings in which a proper proportion of long asbestos fibre is used as a binder, while European practise tends to mix asbestos with a number of different ingredients. Large surfaces, such as may be found on boilers, furnaces, or in ice plants are often covered with asbestos cement, which in America is mostly but a mixture of asbestos and clay and therefore cracks easily, especially if subject to vibration, while in Europe infusorial earth, in itself a good insulator, replaces the clay, and cow hair or soft felt refuse is added to give the mass a better binding quality. Although the application of asbestos cement is most simple, a paste being made by the addition of water and the mixture smeared over the surface to be insulated, a number of rather

thin layers are necessary, each subsequent one being added after the preceding one has dried sufficiently.

In its spun state asbestos is used for insulations, especially in the form of wick for packing pistons and piston rods, valves, cocks, and glands. This application is bound to increase in America with the growing use of superheated steam, as asbestos packing can scarcely be excelled in economy and reliability by other packings, most of which owe the best of their properties to the asbestos contained in

ABOVE, VIEW ACROSS MAIN PIT OF THE BEAVER ASBESTOS COMPANY, SHOWING THE DERRICKS. BELOW, KING'S ASBESTOS MINES, SHOWING DERRICKS AND WIRE ROPE HOISTS.

them; but the addition of vulcanized rubber, metallic wires, and even thin metal sheets is very desirable for a number of special purposes.

Although the fire-resisting qualities of asbestos are suggestive for making paper for deeds and important documents, no satisfactory results have been obtained in this direction on account of the difficulties experienced in making the surface of the asbestos paper glossy and smooth, thus preventing the ink from blurring; but the manufacture of asbestos cardboard, or as it is generally called, millboard, is quite an important branch of the asbestos industry, and that of asbestos paper for structural and insulating uses is many times larger still, affording an important outlet for the fibre. This material adapting itself readily to uneven surfaces, is used extensively for insulating pipe joints, cylinder covers, etc.; it has a very wide range of usefulness in electrical machinery, in the construction of dynamos, in tubes and elbows for turning corners, as accumulator casings, in motors, switchboards and a great variety of other electrical appliances. In its corrugated form asbestos paper is known as air-cell covering and enjoys a lively demand on account of its cleanliness, the ease with which it can be handled, and its great economy in use, as it can be removed quickly and used over and over again if properly handled.

A few years ago patents of Austrian and German origin were taken out in every civilized country for new processes to make roofing shingles out of asbestos, for which purpose the fibre is mixed with other ingredients, making an adhesive mass which is then subject to a strong hydraulic pressure. These shingles can be made to resemble roofing slate closely, but they are of much lighter weight than these; or they can be colored, producing very nice effects on roofs as well as walls of buildings, making them at the same time fire-, water-, and vermin-proof and lessening the variations of temperature within the building to a remarkable degree. This new manufacture has assumed such proportions that many thousand tons of asbestos fibre are now annually consumed in the manufacture of asbestos shingles.

Asbestos paint, plaster, flooring, ceiling, and wall decorations, asbestos bricks, tiles, slabs, and even asbestos lumber, are now used largely in making buildings fireproof. Whole blocks of buildings made entirely of these asbestos materials demonstrate that hundreds of conflagrations do not impair their solidity, as the fire shows in Earl's Court, or on the Vogelwiese and elsewhere, have proved.

MACHINERY AND METHODS FOR THE EXCAVATION OF SKY-SCRAPER FOUNDATIONS.

By T. Kennard Thomson.

Among the engineering developments of the last few years which have sprung from new conditions and created new methods and machinery, few if any have been more impressive than that of the tall building. It has been freely discussed in its architectural and structural aspects. Mr. Thomson presents it in a new phase—that of the mechanical plant and processes which it assembles.—THE EDITORS.

THE introduction of sky scrapers, only a few years ago, has not only revolutionized the amount of plant required to run these immense buildings but also brought into play much ingenious contractors' plant and a higher grade of contractors.

The permanent machinery for these buildings takes up much room, which, of course, can not be spared either from the ground floor or basement under the street floor, so that not only have sub-basements been put in, but also cellars and sub-cellars under them, making from two to four floors below the street level, the first of these being the addition to the Mutual Life Building on Cedar and Liberty Streets, New York, in 1900-1, which caused the words "Earth Scraper" to be coined.

The construction of these buildings also requires a very elaborate temporary plant—that is, derricks, cranes, pumps, electric-light plant, hoisting engines, compressors, air receivers, air coolers, rock drills, pile drivers, etc., all of which must be quickly brought to the site as needed and as quickly removed. The illustrations show typical examples of building sites completely covered with caissons and temporary plant, all of which disappear from sight before the erection of the steel work starts, the caissons being sunk until the tops are 15 to 20 feet below the street level and the plant all being removed.

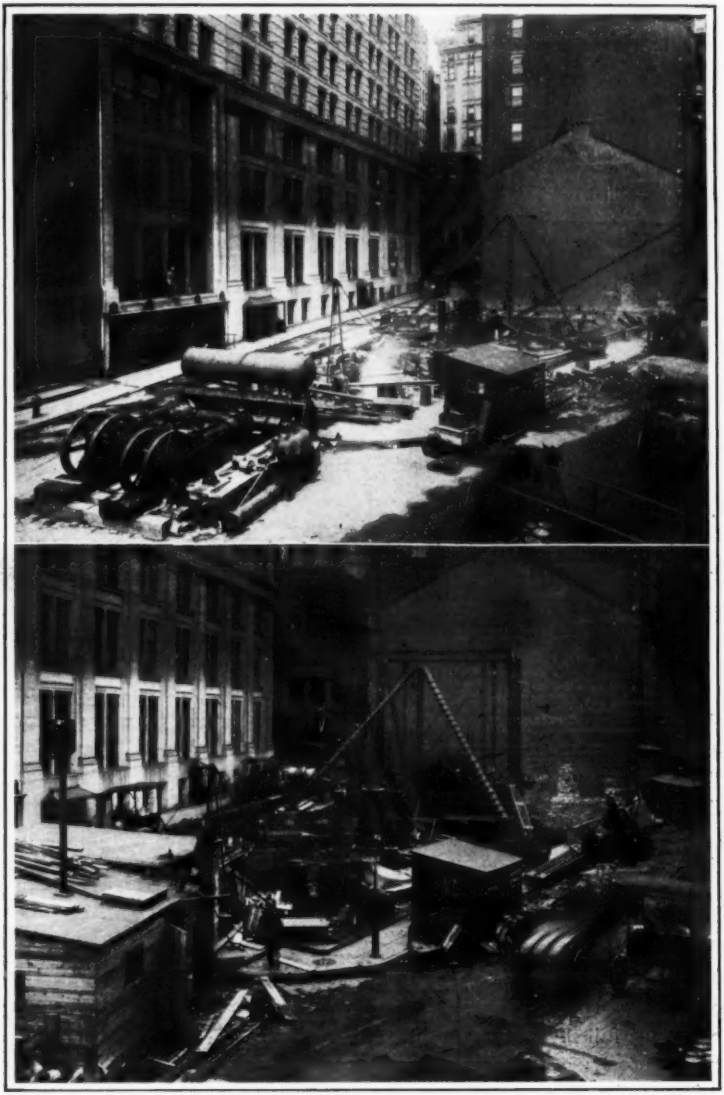
This is especially true where the foundations are carried to bed rock by means of pneumatic caissons—as, indeed, all buildings in lower New York should be, on account of the bed of quicksand from 30 to 60 feet thick, which covers the whole of this part of the city. This quicksand makes a good foundation provided it be confined and no opportunity be afforded of escaping into some adjoining and deeper excavation for other buildings or tunnel. This danger is exceedingly apt to occur where the building is placed on this material, for it is so fine that it will run wherever water will and soon leave a big cavity

THE NEW YORK SKY-SCRAPER LINE, WITH THE NEW SINGER BUILDING INTRODUCED AS IT WILL APPEAR.

behind for the new or old structures to fall into. As we know, the subway tunnels are fairly close to the surface, but soon we will have tunnels from Brooklyn to Jersey which must, perforce, run below the present tunnels, and it is quite probable that we will, ere long, have other tunnels crossing under these again, so that no foundation above good hardpan or bed rock can be considered safe or economical for a sky scraper.

In Chicago, they put off using caisson foundations much longer than in New York, but the settlement has been so great (some of the big offices on what are called spread or floating foundations having settled two feet or more) that they are now coming around to rock foundations in Chicago, too. It is, however, only 14 years or so since that eminent architect, Mr. Francis H. Kimball, insisted upon using pneumatic caissons to bed rock to support the Manhattan Life building at 66 Broadway. At that time, he was very severely criticized for spending so much money to get a safe understanding; but within the last few years, the public has begun to see the wisdom of following the advice given in the Bible about building on rock.

One result of these high structures is the obliteration of old lot lines, for no one desires to erect a sky scraper down town on a single 25-foot lot, preferring, where possible, to absorb the whole block which, of course, gives the best chance for economical construction. When the investor has obtained two or more lots and selected his engineer and architect, he generally lets a contract for the removal of the old and generally ramshackle house—the reverse of an ordinary contract, for, in this case, the contractor usually pays the owner for the privilege of removing everything above the street or curb level, the price obviously depending on what the house-wrecker thinks he can sell the old material for. Generally the old brick work, set in lime mortar, can be removed by hand without using any force; but occasionally the wrecker runs up against a comparatively new and well built affair, like the Coal and Iron Exchange on the corner of Cortlandt and Church Streets in the removal of which dynamite is required, greatly increasing the expense and decreasing the value of the material taken out. These contractors often leave the old basement full of rubbish up to the street level for the foundation contractors to remove. It might be stated here that, before the advent of caissons, the old cellars were necessarily above the water level (which, in lower New York, is from 15 to 25 feet below the street level and generally a few feet above the high-tide level in the bay) and the old walls were seldom carried more than 2 feet below this level. Many of the older walls are supported by piles which, however, are unre-

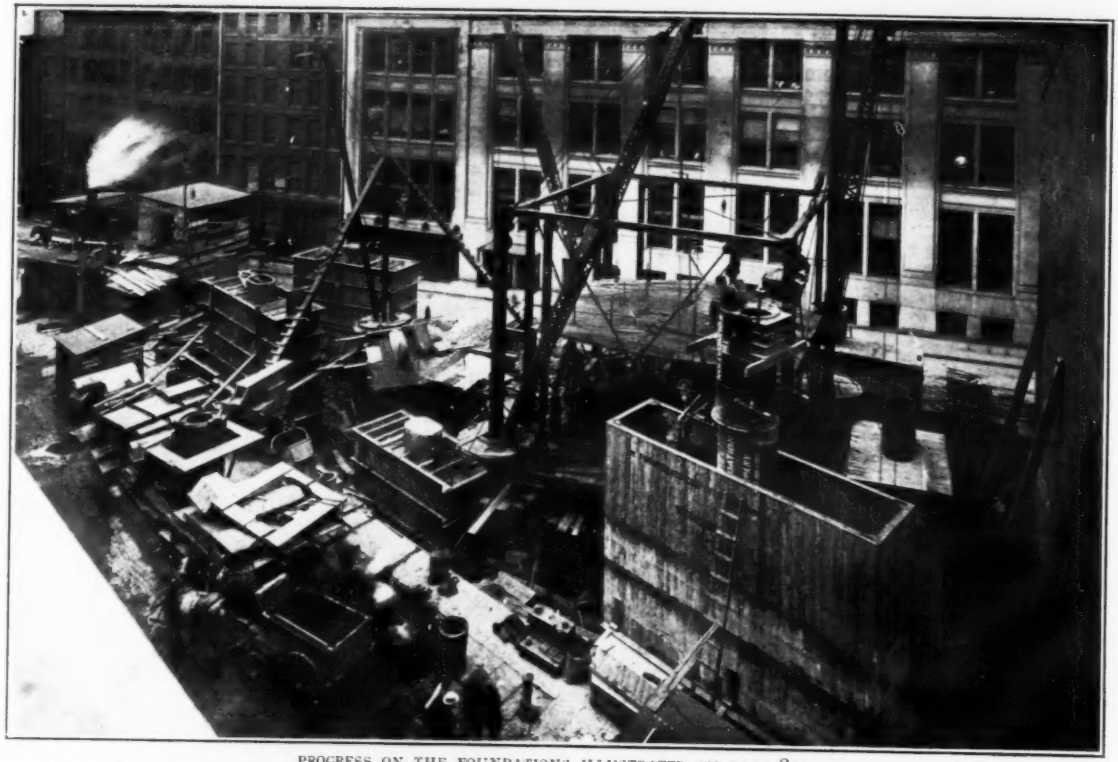


TWO STAGES IN THE PROGRESS OF FOUNDATION WORK FOR A NEW YORK SKY SCRAPER.

In the earlier one, above, the erection of the air-compressors has begun—two Ingersoll-Rand machines, one 19 by 22 and one 18 by 20, with a total capacity of 660 cu. ft. of air per minute. In the later stage shown below the compressors are housed, a Smith concrete mixer is being lowered, and a four-masted derrick is being put up.

liable for they depend, of course, on the friction of the earth against the sides of the piles, and if the new operation should draw the material from around the piles, the frictional resistance would vanish and a collapse might result; in fact, this did happen in the case of a $400,000 wharf in Baltimore recently, where the superstructure was carried on an immense number of piles which had no frictional support for some 35 feet under water.

Where caissons have been decided on, the foundation contractor often lets a sub-contract for the removal of material from the street level to the water level, to men who confine themselves to this business. It might be stated here that in the country excavation can be done for 25 cents per cubic yard similar to that which, in New York, costs from $2.00 to $3.00 per cubic yard. At other times the head contractor will erect one or more stiff-leg derricks to handle iron buckets holding from 1 to 2 cubic yards each, which raise the material from the cellar and dump it into wagons which are, in turn, dumped onto scows and the load towed away, all bringing the cost up to the above figures. The next step (see the top of page 84, which shows the preparations of the Foundation Company at the junction of Maiden Lane and Liberty Street) is to erect the air-compressor plant. The air receivers here, shown in a horizontal position, are two, 41 inches in diameter and 16 feet long, and the air cooler shown between the compressors and receivers consists of a pipe 16 inches in diameter and 12 feet long, filled with gas pipes. A continual stream of cold water keeps the pipes cool and prevents the air from getting too hot. Sometimes the air is passed through a number of gas pipes which are kept bedded in and covered with ice—rather an expensive arrangement. Occasionally the cooling apparatus gets out of order, and the air in the caisson gets so hot (I have felt it over 106 degrees) that the men can not or will not work. The lower view, taken 5 days later, shows the compressors, etc., all housed in and a four-masted traveling derrick partially erected. This derrick takes the caissons off the wagon and lands them in place and handles all the material on the job. The first of these derricks was designed by me for the Commercial Cable building on Broad and New Streets in 1896, and the second for the Mutual Life Building in 1900. Since then many have been built, chiefly of wood, but the one shown in this photograph is the first and only one to be built of all steel and is the most up-to-date and best of its kind ever erected. It was first built by the Foundation Company last year for the Trust Company of America Building on Wall Street. On July 10, 1907, four days later, this derrick was entirely ready for use, and the picture on page 86



PROGRESS ON THE FOUNDATIONS ILLUSTRATED ON PAGE 84.

In this view, taken sixteen days after the upper one on page 84, and eleven days after the lower one there shown, the four-masted derrick is in full use and five caissons are in place.

taken on July 17, one week later, shows five caissons in place and the work in full blast, the compressors being boxed in, and offices, sheds, etc., built on top.

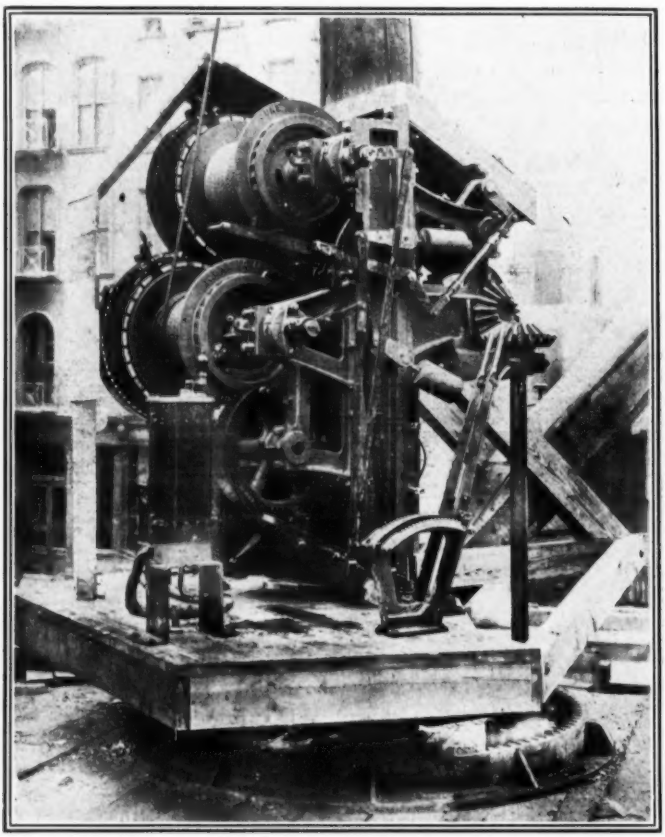
These four-masted derricks are rather too expensive to be built for a single job, and a steel derrick is obviously much better adapted to being taken apart and put up again than the old style of wood, for the members are naturally held together by bolts which are supposed to fit tight in the holes. Of course, if a bolt is repeatedly driven in the same hole, it enlarges the hole and spoils the tight fit, especially in wood.

UNWATERING A CITY BUILDING FOUNDATION.

Cameron steam pumps draining the excavation for new Edison Power House. It is one foot below low tide and 21 feet deep, and there was much water.

On a small job, one of these travelers is sufficient; but on a large site, like the City Investing building on Broadway and Cortlandt Street, two or more are used, and also a number of stiff-leg derricks, and, at the same time, the compressor and other mechanical plant also increases in some cases, until the capacity reaches 3,000 or 4,000 cubic feet of air per minute. The early traveler we built had an ordinary two-drum hoisting engine, about 7 by 10 or 8 by 10 inch cylinder, with a vertical 25 to 40 horse-power boiler for each boom; but now, wherever possible, the boiler is done away with, getting rid of the nuisance of coal, smoke, etc., and the engines are run direct by

city steam which is also used to run the compressors, drills, etc., thereby saving not only much annoyance to the public, but also much valuable space.



STIFF-LEG DERRICK WITH HOISTING GEAR ATTACHED TO MAST.
Lidgerwood hoist, General Electric direct-current motor, capacity 4,000 lb. at 130 ft. per minute.

Each boom is capable of lifting from 10 to 20 tons. When hoisting the bucket out of the caisson, speed, of course, is the principal object, so a single steel cable of 5/8, 3/4 or 7/8-inch wire rope is used, leading direct to the engine; but when heavy loads are to be lifted, it is "doubled up" or changed to four lines by means of blocks. Much ingenuity has been displayed in getting up schemes for making quick changes from single to double lines, for from 15 to 20 minutes

a change is an expensive delay on a big rush job, with all the sand-hogs and other labor waiting for the bucket, etc. These booms, on a well designed derrick, are capable of swinging through an angle of about 270 degrees horizontally, and can be lowered to the ground or raised nearly vertical, giving a very wide range of action.

Of course, no caisson work would be carried out now without electric light, and an ample supply of fresh water; so for bridge caissons outside of the cities, a complete electric-light plant and pumping plant are at once installed, but fortunately in New York satisfactory terms can be made to tap the nearest pipe and wires. In fact, on two jobs this year, the City Investing building and the Cortlandt Street terminal, the O'Rourke Company had the entire plant equipped for electrical power, being the first foundation jobs to be so handled. The pictures on these facing pages show a stiff-leg

A COMPLETE VIEW OF THE STIFF-LEG DERRICK OF WHICH THE HOIST IS SHOWN OPPOSITE.

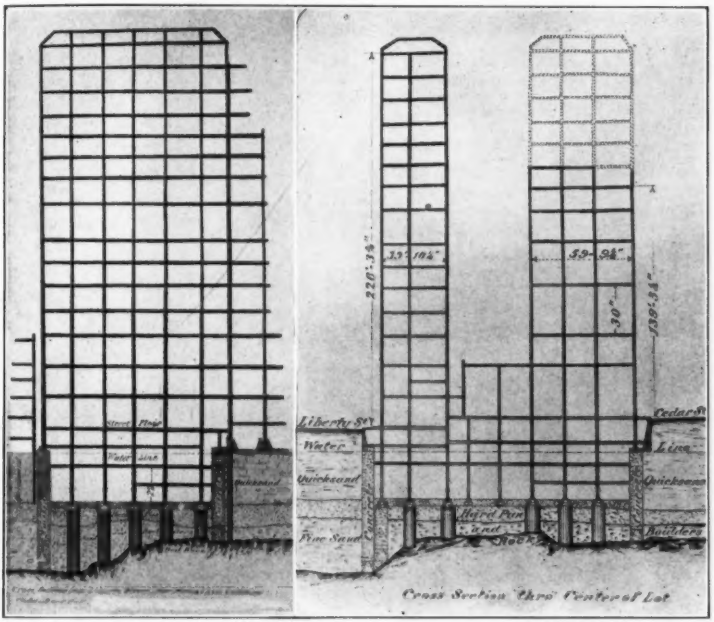
derrick with the hoisting gear attached to the mast. These are made for two- or three-phase current, 60 cycles, 110, 220, 440 and 550 volts, General Electric alternating-current induction-motor hoists, with friction drum and solenoid brakes, and in sizes from 15 to 150 horse power. This new type of electric-mast hoist as developed for these buildings is complete in itself, containing not only the electric motor,

controller, and resistances, the two drums for operating the boom, and the fall lines of the derrick, but also the boom-swinging gear, giving the operator full control of his work which he is all the time facing. This machine is certainly compact and is also capable of high power and reliability.

The hoist shown in the view on page 88 was operated by a 250-volt direct-current General Electric motor, with a nominal capacity of 4,000 pounds lifted at a speed of 130 feet per minute; the drums, 12 inches diameter and 19-¾-inch face, were each complete with brakes, ratchets and pawl. In addition to the regular brakes, operated by foot levers, it was also equipped with electric solenoid brakes. This brake is applied to the shaft of the electric motor. When the operating current is turned onto the motor, it passes through the coils of the solenoid, lifts the armature, and automatically releases the brake. When the current is shut off, or in case it is cut off by accident, the armature falls, and its weight sets the brake with power to support the entire load of the hoist. The current to operate this hoist is claimed to be only one-half a kilowatt hour to lift a bucket weighing 2,200 pounds with its load out of the caisson and to return it empty to the air chamber.

Before the first contract for the foundations is let, and often before the old buildings are vacated, borings are made in the old cellars to ascertain where rock is and the nature of the intermediate material. These generally consist of wash borings made by forcing a pipe of about 3 inches (more or less) in diameter into the ground by means of a small pile driver, built for the purpose, and a free use of the water jet. These borings are only reliable as an indication of the depth of hard pan below the surface, for they very seldom penetrate the hard pan and reach bed rock, although this has been accomplished by occasionally dropping a small stick of dynamite and exploding it in the hole after the pipe has been raised a few feet.

The result of these insufficient borings usually is that a lump-sum contract is let on condition that the caissons are carried down to the depth shown by the borings, with an additional price per cubic yard for each additional cubic yard excavated. Occasionally diamond-drill or core borings are made and the core is taken out until the drill has bitten several feet into the rock. But while the top of hard pan is fairly level, and it is easy to arrive at a fair average level for it, New York bed rock, gneiss, is just the reverse, and it would take an immense number of diamond-drill borings to get a reliable average depth. Before commencing to sink any of the caissons, it is necessary to see that the adjoining buildings are safely shored up or under-

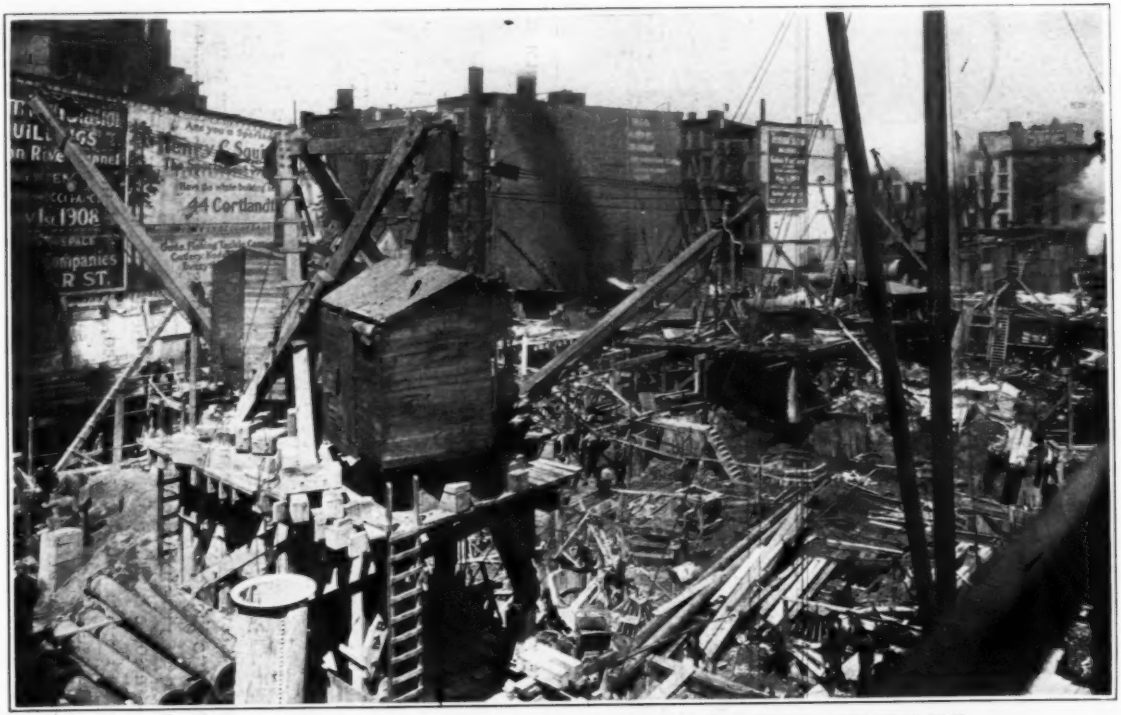


STEEL WORK, CAISSON FOUNDATIONS AND SUB-CELLARS OF A TYPICAL TALL BUILDING.
The Mutual Life Building, Cedar and Liberty Streets, N. Y.

pinned, sometimes a very serious matter, which has cost as much as $75,000.

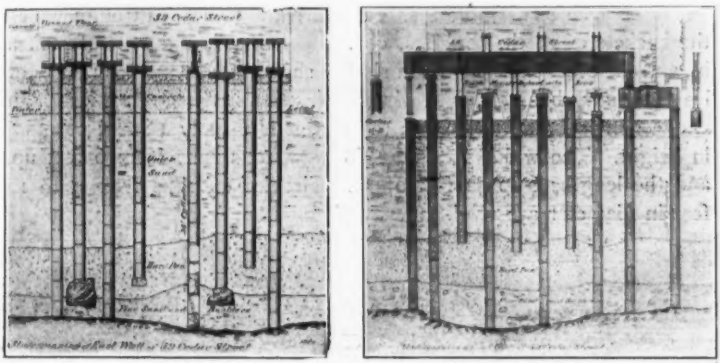
If the building is small, it is often sufficient to put a few inclined shores or 12 by 12 inch timbers, say 20 to 30 feet long, up against the side of the wall and rest them on sills placed on the ground. When the building is heavier, one of the oldest methods is to cut a hole through the wall and insert one or more wooden or steel beams, called needles, supported by sills in the old cellars of the adjoining buildings and the new lot. The centre of the beams being directly under the wall to be supported, the weight of the wall is then transferred to the beams by means of wooden or steel wedges or hydraulic or screw jacks or other means.

In some cases even this is not sufficient, and as it takes up a great deal of space which can ill be spared, a patented method has been developed of driving small caissons, say, 3 feet in diameter, under the wall, one at a time. This has been done so successfully that when the new foundation of an 18-story building had thus been transferred to rock, 60 feet below the old foundation, there was not



FOUNDATION WORK IN FULL PROGRESS, CHURCH STREET TERMINAL BUILDING, NEW YORK CITY.

a settlement of 1/16 inch, causing the president of one of the safe-deposit companies to testify that a possible financial panic had been averted by the care with which the underpinning had been done; for, said he, had the building been allowed to settle even 1/32 inch, the doors of his vaults would have been thrown out of gear, Wall Street would have wakened up some morning and not been able to get at their securities, with the result of a panic.

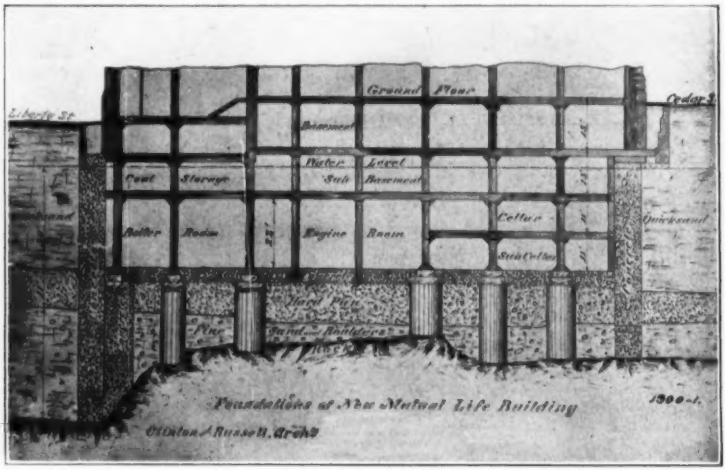


UNDERPINNING IN SKY-SCRAPER FOUNDATION WORK.

Like everything else in foundation work, the underpinning for each individual case is a study by itself. The left-hand cut shows a building under which the last of these small caissons is just being put in place. The outside diameter of these particular caissons was 36 inches and the inside 33 inches, leaving very little space for the men to work. Looking closely at the fourth column from the right, it will be seen what cramped quarters the sandhog has. He is shown chipping off the rock at the cutting edge. About 8 feet above the cutting edge is an air lock 8 or 10 feet high in which a lock-tender is waiting to pull the material in canvas bags up into the lock. When he has pulled four or five bags up that way, he closes the lower door and allows the air in the lock to escape, thus removing the pressure which holds the upper door shut. The air pressure having fallen to atmospheric, the bags are drawn up the shaft and emptied outside, and finally concrete is taken through the lock until the air chamber is sealed with concrete, when the air is taken off, and the rest of the cylinder filled with concrete. This is naturally a very expensive as well as the most reliable method, and can easily cost as much as $200 per cubic yard of material removed, including the cost of the cylinders, jacking, wedging, etc.

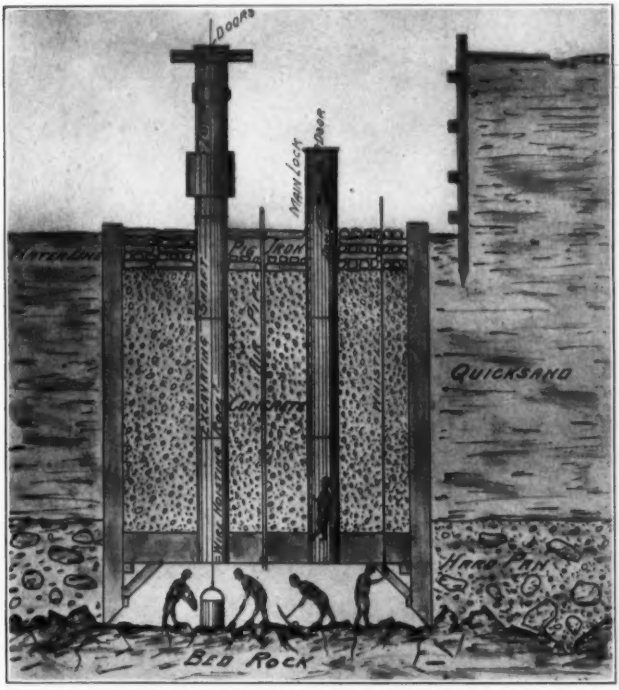
The adjacent walls having been safely secured or, at least, those

walls near where the first caisson is to be sunk, the contractor is ready to start the most important part of the work—the caisson proper. It might be stated here that a pneumatic caisson is built in the shape of a box, having four sides and roof but no bottom, the bottom of the sides being called the cutting edges. The roof or deck has one or more holes, 3 feet in diameter, and over these holes are bolted 3-foot steel shafts. The drawings opposite show a large caisson with two such shafts, one marked "excavating shaft" through which the buckets of earth, boulders, etc., are removed, and concrete taken in, and the other marked "main shaft," showing how men can enter or leave the air chamber. The air chamber is usually 6 or 7 feet high and, when the caisson reaches the site, it is usually 12 feet or more in height. The width for New York caissons runs from 6 feet up, and the lengths 6 to 30 feet or so. Circular caissons from 5 to 12 feet in diameter are used, but not often in the large sizes.



FOUNDATIONS AND LOWER STEEL WORK, MUTUAL LIFE BUILDING, NEW YORK.

When a caisson has been placed in position by means of derricks, the caisson men (called "sandhogs") enter the air chamber to undermine the cutting edge, and shovel the material into the buckets, which are about 29 inches in diameter and about 3 feet high, containing about ½ cubic yard. While they are doing this, other men are placing concrete on top of the roof or deck to form part of the permanent foundation and, at the same time, to add weight to the caisson to force it to follow the excavation below the cutting edge. A great weight is required for this purpose, for not only has the friction on



A LARGE CAISSON WITH ITS SHAFTS.

the sides of the caisson (which runs from 50 to 650 pounds per square foot of surface) to be overcome, but also the pressure of the compressed air against the roof of the caisson. It might be stated here that the only object of using compressed air is to prevent the water from flowing into the air chamber where the men are working, and therefore compressed air is used only where water is encountered; and the pressure of the air must always equal the pressure of the water, for, if the water pressure is greater, the water will flow in, and, if the air pressure is greater, the air will "blow out" with more or less serious results.

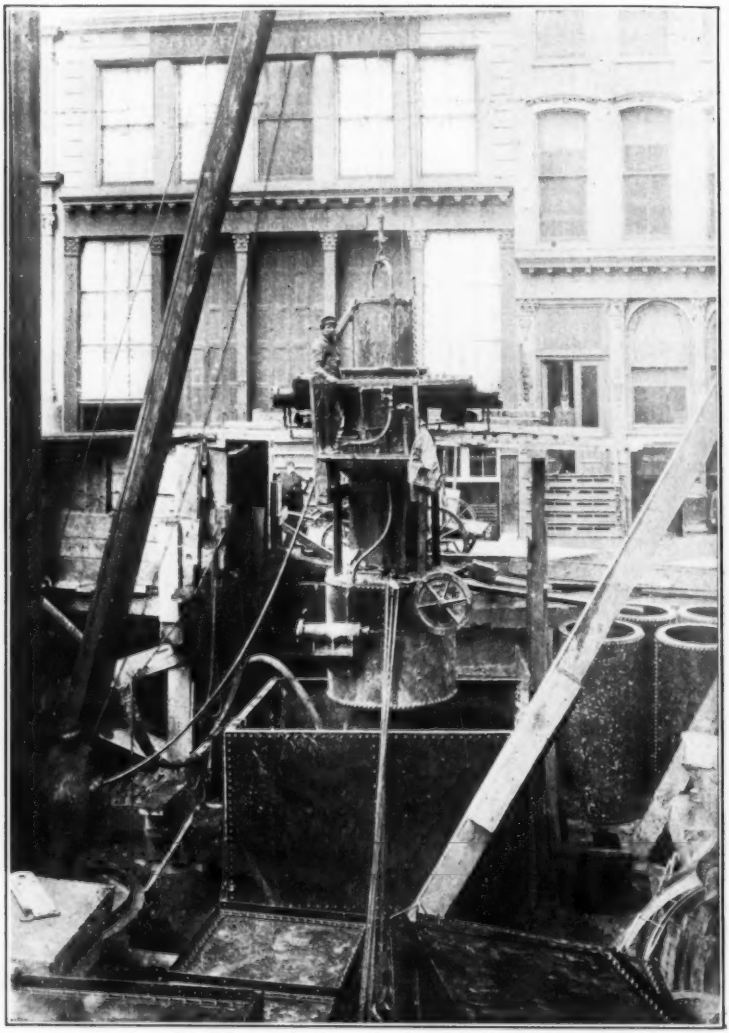
Now, we know that a cubic foot of water weighs 62-½ pounds, 10 cubic feet, 625 pounds and so on, and this is equivalent to .434 pounds per square inch, or nearly ½ pound per square inch of surface for each vertical foot of water; so if the cutting edge is 1 foot below water, ½ a pound of air would be required and if the penetration were 100 feet then the pressure would be 43-½ pounds per square inch, in addition to the atmospheric pressure, which is about the limit

THE CITY INVESTING BUILDING AND THE NEW SINGER BUILDING WITH ITS 41-STORY TOWER, NEW YORK CITY.
TWO OF THE LATEST AND GREATEST "SKY SCRAPERS," NOW UNDER CONSTRUCTION.

of human endurance. The illustration at the top of page 95 shows a large caisson in its final position with all the cofferdam on concrete on deck and additional weight, pig iron, required for sinking. As the cutting edge is undermined, the sides of the caisson (called cofferdam, when above the deck) are built up and filled with concrete. The cofferdam, necessarily, must be built up as fast as the caisson sinks, so as to keep its top always above the ground; otherwise the ground would fall into the cofferdam. The steel columns which rest on top of the caissons have broad bases to distribute the strain over the entire surface of the concrete, and these bases are generally kept below the lowest floor level to economize room, thus limiting the height to which the concrete can be built on the deck or roof; the result often is that the concrete does not weigh enough to force the caisson all the way down, and it is necessary to add more weight, which most often takes the shape of pig iron or heavy cast-iron blocks, frequently to the extent of hundreds of tons even on a small caisson.

WORKMEN ENTERING AIR LOCK, PREPARATORY TO DESCENT INTO A FOUNDATION CAISSON.

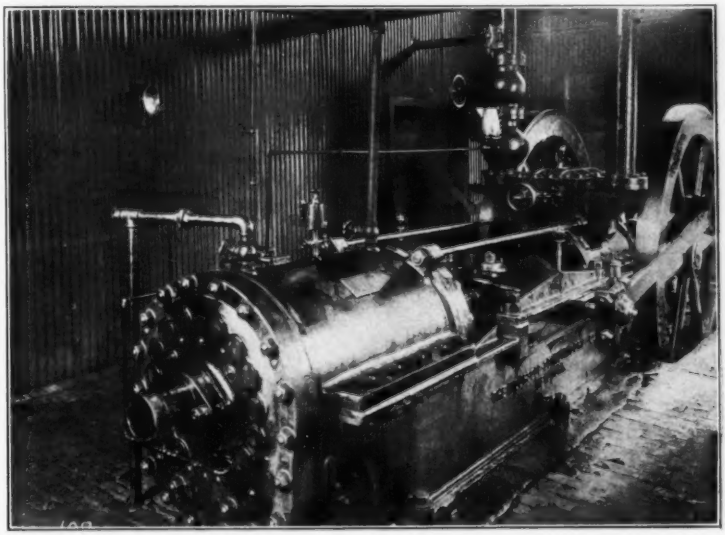
The deepest caisson put down in New York City is under the Mutual Life building, where we penetrated 100 feet below the street level, or 85 feet below water line with the foundations, while the cellar floor was stopped 35 feet under the standing water level. On



A FOUNDATION CAISSON TOP AND AIR LOCK.

the Cedar Street side, there are four stories underground (see page 94 while on the Liberty Street side there are only three, the bottom one being 22 feet high; two ordinary cellars, to make room for the boilers, etc., the floor immediately above being used for coal.

But to come back to the caissons; they are built of wood, steel, or concrete or some combination of these three, and, of course, have pipes carried down through the concrete to keep up the supply of compressed air, as well as a small gas pipe with a whistle on top so that when the sand hogs want to signal to the man outside, they open the valve of the gas pipe in the air chamber, allowing the air to rush out and blow the whistle. One whistle means "hoist the bucket"; two, "hold the bucket where it is"; three, "lower"; five, "the gang want to go out, etc."



AIR COMPRESSOR PLANT FOR A CITY EXCAVATING JOB.
Ingersoll-Rand compressor, Class A, 30-inch stroke.

In big river caissons and tunnels, telephones are used, but they are very seldom used in city work. Sand hogs work in 8-hour shifts —that is, three gangs in 24 hours, each gang taking half an hour for lunch and 7-½ hours for actual work, for which they receive $3.50 a day, until the air pressure exceeds 20 pounds per square inch. As the pressure increases the pay increases, but the hours of labor decrease until at 45 pounds (in addition to atmospheric) the men only work 1½ hours a day, and even that is divided into two shifts of ¾ hour each and 4 hours apart; this is all the men can stand, and even then there is great danger of the bends, or worse, of being paralyzed. Many can not even stand the light pressure.

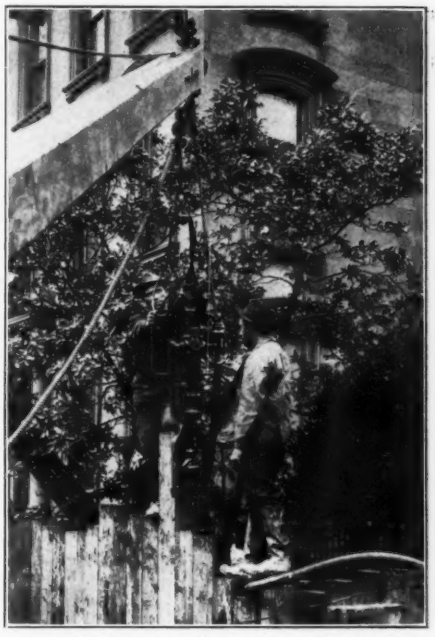
DRILLING IN ROCK FOR SKY-SCRAPER FOUNDATIONS.

The first effect generally noticed when the air is let into the lock is the pressure of the air on the ear drums, and if this pressure is not quickly equalized, the ear drum is ruptured, of course, for life. At other times, this plugged sensation results in blood vessels being ruptured in the head which danger is much greater if the person has a cold to start with. In fact, if one has a cold or anything wrong with his heart or lungs, he has no business to try to enter the lock at all. Even men in apparent perfect condition can not always stand it. A lock might be described as a small room with two doors like the vestibule of a house, so that if one enters and shuts the outside door before opening the inside door only the amount of air contained between the two doors is lost in passing in or out. It is necessary to have an air lock to prevent all the air escaping from the air chamber every time men or material pass through the lock, for if all the compressed air were allowed to escape from the working chamber, even for a very short time, the chamber would quickly fill up with mud and water, with probably disastrous results to the adjoining buildings, to say nothing of the loss of human life. When the compressed air is allowed to enter the lock too quickly, and sometimes even when considerable time has been taken in entering and leaving the lock, it is supposed that the air bubbles force the blood away from the surface and then, when coming out of the compression, many of the bubbles remain in the system, which results in the "bends," a very painful experience. The attack is usually in the arm or legs. The longer one stays in compressed air and the more exertion taken in it, the greater the risk of the bends, which, however, often do not make themselves felt for several hours after coming out, although some claim that they can tell that they are getting the bends while still in the air chamber. The worst form of caisson disease is paralysis, from which some die at once, some recover, and others are afflicted for the rest of their lives; and which it will be none can tell. Many of the old watchmen seen on these jobs humping around with a cane are such victims.

A school girl was once asked where could you walk the faster, on top of a high mountain, where the pressure is very much lighter than what we call atmospheric (nearly 15 pounds per square inch) or down in a caisson where one has to carry say 20 to 40 pounds on every square inch of the body in addition to the atmospheric. At first she thought on top of the mountain, but quickly corrected herself by saying: "Of course not, for more work could be done in the compressed air on account of the great supply of oxygen." The excess of oxygen not only gives the men great energy and appetites—you see seldom a

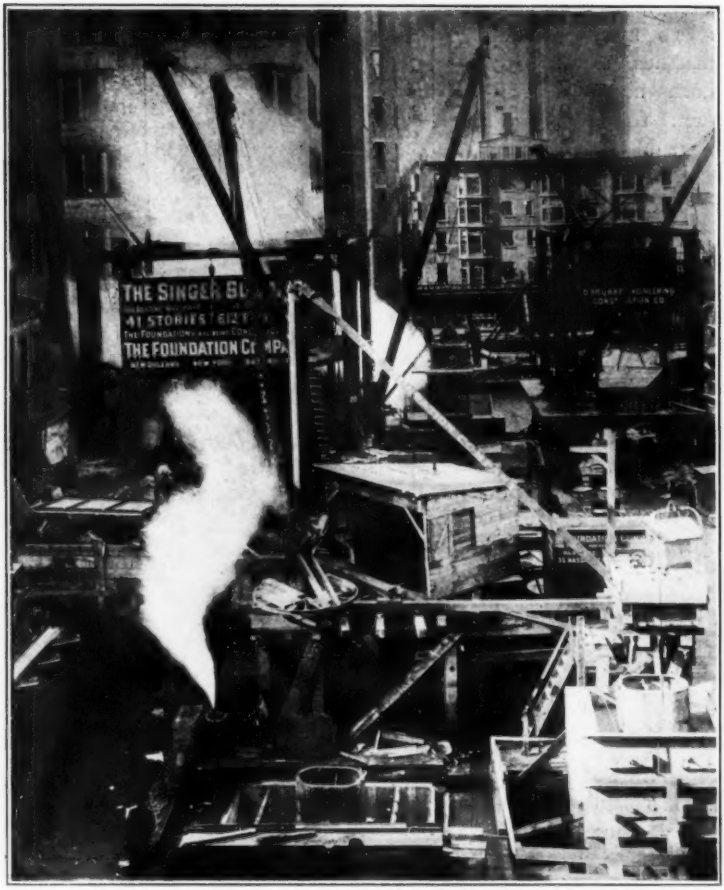
NORTH TRINITY AND U. S. REALTY BUILDING, WHERE WORLD'S TIME RECORD WAS MADE IN 1906.

thin sand hog—but it also makes candles, matches, cigars, etc., burn much faster; in fact, frequently, men have blown out a candle and put it in their pockets, only to find their coat on fire in a few minutes. One seldom sees an old sand hog; they must burn up their energies. It has often been a matter of comment that even the best of sand hogs are about useless if given an outside job; whether they lose their inclination or ability to do good work, I know not.



INGERSOLL-RAND DRILL USED AS A PILE DRIVER.

When the sand hogs have removed all the material in the air chamber above good hard pan or bed rock, they fill the air chamber with good Portland-cement concrete, gradually backing up to the shaft until there is a solid mass of concrete, with the exception perhaps of the wooden or steel roof from the bottom of the foundation or bed rock up to the base of the columns. When the cellar is to be above the water line, the caissons are sunk to support the individual columns only, but when the excavation for the cellar has to be carried below the water line, it is necessary to put a continuous line of caissons around the entire lot and then put a water-tight joint between them, in which case the entire interior is sometimes excavated before the columns are placed and, in other cases, caissons are used for the interior columns also. While the pictures on pages 84 and 86 of the building between Maiden Lane and Liberty Street now under construction show a marvelous amount of work done in the first 19 days, the world's record for rapid caisson sinking is held by the Foundation Company, who, last year, sank and sealed 87 caissons for the North Trinity and United States Realty buildings on Broadway in 60 days, taking only 30 days for the last 57.



CONTRACTORS' PLANT AND MACHINERY, FOUNDATION OF THE 42-STORY SINGER BUILDING, N. Y. CITY.

There is a limit to the space allowed for this paper, but there is no limit to the subject, as a dozen or more branches of it which have been merely alluded to would require more space than this whole article to do them justice.

APPLIED ELECTRO-METALLURGY UP TO THE END OF 1906.

By John B. C. Kershaw.

Mr. Kershaw has condensed, into a remarkably close compass, an admirably clear view of the advance of electro-metallurgy up to the present year. It is significant of the extent of the development that even so concentrated a summary of its data exceeds the space of a single magazine article, and we have to reserve for next month another very interesting section, covering among other things the latest progress in the manufacture of ferro-alloys and of iron and steel direct from the ore—THE EDITORS.

THE electro-metallurgical industries are the growth of the last twenty years, but in that period very remarkable progress has been made. Only one industry existed prior to 1886, namely that of copper refining; this was carried on in a few works upon an extremely limited scale of operations. Today, the electrolytic copper-refining industry is second in importance only to that of copper smelting, and over one-half of the world's production of copper is submitted to the former process. The manufacture of aluminium, calcium carbide, carborundum, ferro-alloys, and sodium are other important and expanding electro-metallurgical industries, while the application of the electric furnace to steel refining is a new development which may lead to very important changes in the iron and steel industries—for in conjunction with gas engines and dynamos, it may serve as a means of utilizing the enormous power now lost in the waste gases from our blast-furnaces.

The following pages deal with the various electro-metallurgical industries in alphabetical order, describing briefly the processes or methods in use and the extent to which these methods have been applied upon an industrial scale.

ALUMINIUM.—The manufacture of aluminium by the electrolytic method was commenced at New Kensington in America in the year 1888, and at Neuhausen in Switzerland in the year 1889. The processes were worked out independently, by Hall in America, and by Heroult in France, but as now operated they are practically identical, and consist in the electrolysis, with carbon electrodes, of aluminium oxide held in solution in a fused bath of cryolite and fluorspar. Since the introduction of the electrolytic method of manufacture in 1889 the production of aluminium has increased from 85 tons to

POWER PLANT, LA PRAZ WORKS OF THE SOCIÉTÉ ELECTRO-METALLURGIQUE FRANÇAISE.

12,000 tons in 1906. The following tabular statement shews the gradual increase in output and fall in price which has marked the industrial development of the electrolytic process:—

Year.	Production Tons.	Price Pence per Lb.	Year.	Production Tons.	Price Pence per Lb.
1885...	3.12	600	1896	1,755	17.0
1886...	14.80	500	1897	3,327	17.5
1887...	22.50	400	1898	3,953	16.2
1888...	39.40	250	1899	5,459	16.2
1889...	85.20	125	1900	7,192	16.0
1890...	174.50	100	1901	7,420	15.5
1891...	345.50	125	1902	7,750	15.5
1892...	485.00	32	1903	8,102	15.5
1893...	713.00	...	1904	8,550	15.5
1894...	1,057.00	25	1905	9,000	16.0
1895...	1,129.00	22	1906	12,000	21.4

Note.—The production is given in tons of 2,240 lb. and the price in pence per lb. From 1902 onwards the production figures are estimated, and from 1897 to 1904 the figures for price are based on the American values.

The manufacture of aluminium is now carried on in a number of works, controlling over 84,000 horse power. Details of these so far as they are known, are given below:

Name of Company.	Locality of Works.	Horse Power.
1. British Aluminium Co.	Foyers, N. B.	5,000
	Norway	10,000*
	Switzerland, in course of erection	45,000*
2. Société Electro-Metallurgique Française	La Praz	7,500
	Gardannes	7,500
3. Compagnie des Produits Chimiques d'Alais	Calypso	10,000
	St. Felix	2,500
4. Aluminium Industrie Aktien-Gesellschaft	Neuhausen	5,000
	Rheinfelden	5,000
	Lend Gastein	15,000
5. Compagnia Italiana	Pescara	3,000*
6. Pittsburg Reduction Co.	Niagara Falls	10,000
	Shawinigan Falls (Canada)	5,000
	Massena (U. S. A)	12,000

Assuming that 4 horse power are required for one year, to produce one ton of aluminium, the aggregate power available in these works would suffice to produce 35,000 tons of the metal per annum. Owing, however, to the diminished power available during the summer droughts and to other causes, the maximum total of power is not available for the manufacture all the year round, and my estimate of the 1906 production is about 12,000 tons.

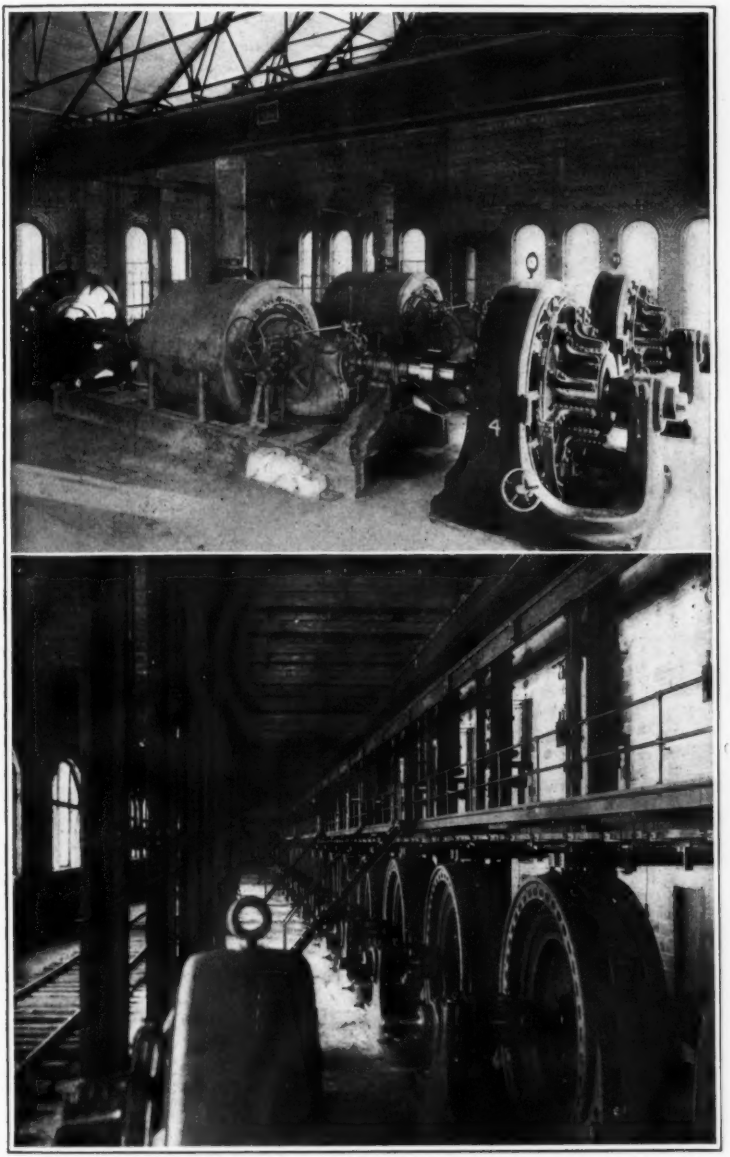
* On the authority of the *Revue Industrielle*, 1907, page 222, as quoted in *L'Industria*. —Ed. E. M.

The past year has been marked by the expiration of five of the United States patents granted to Hall in 1889. The Heroult patents lapsed in Europe in 1902, and the manufacture of aluminium by the electrolytic method can therefore now be carried on without the payment of patent royalties. The use of the electric current for keeping the bath in the molten state is however still covered in America by the Bradley electric-furnace patents which do not expire until 1909. In that country the Pittsburg Reduction Company therefore still possess the monopoly of the electrolytic reduction process.

As regards utilization, the demand for the metal in Europe during 1906 has been in excess of the output, and the reduction plants are being extended in several of the works, in order to benefit by the higher prices now obtainable for the metal. The British Aluminium Company, in addition to the development of a new water power in Switzerland, are carrying out a very large scheme on Loch Leven in Scotland, which when completed will add enormously to their power resources in Scotland. The Aluminium Industrie Aktien Gesellschaft, of Neuhausen, are likewise developing a large power scheme on the River Navisonce in Switzerland, from which it is expected that 25,000 horse power will be derived. A new aluminium works also has been erected by an Italian Company in the Valley of Pescara in Northern Italy, and is about to commence operations. In a few years, therefore, the productive capacities of the aluminium companies will be more than doubled, and it will be of interest to note whether the demand shews a similar expansion.

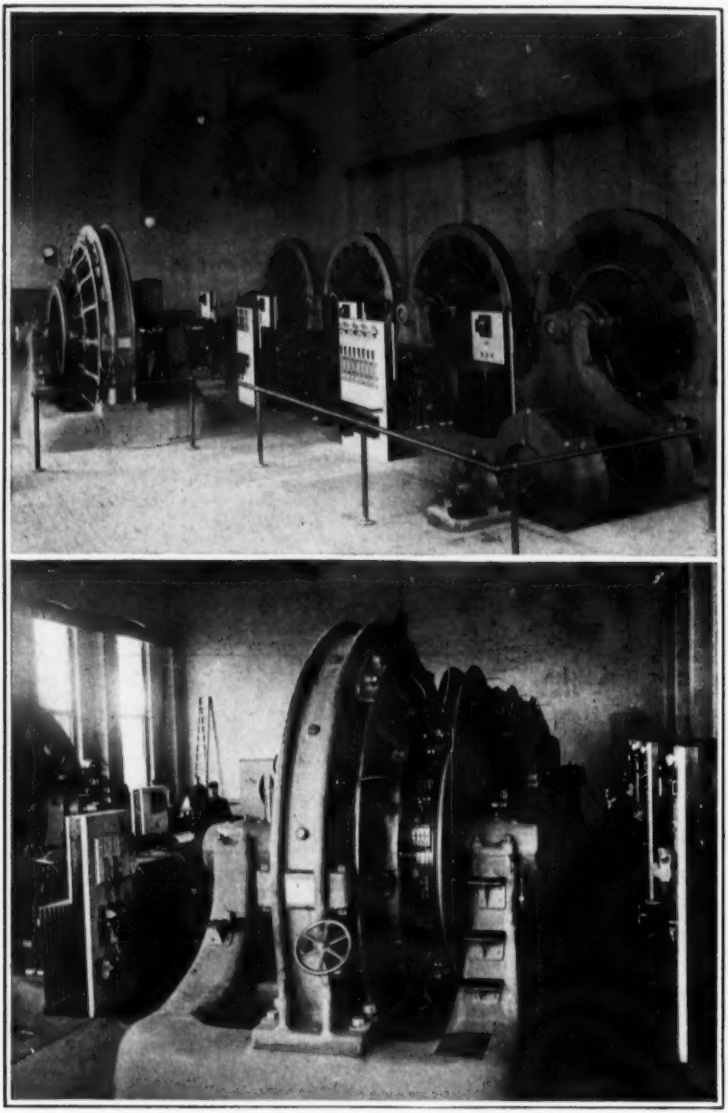
The metal is now being used in very large quantities for motor-car construction, and for general foundry work, while the "Thermit" and "Weldite" processes also consume large quantities of aluminium in the form of powder. In every direction in which the metal has been applied with success, its use has increased during 1906.

Mr. Schoop of Paris has worked out the details of a process for the autogenous welding of aluminium, which overcomes the difficulty of finding a suitable solder for the metal. By this process aluminium sheets, rods, or tubes, of any thickness, can be welded without any difficulty, and the joints are said to be as strong as the other parts of the metal. This method of welding will probably lead up to increased consumption of the metal in many industries, and to its use for larger articles and vessels than have yet been manufactured from it. Another direction in which the use of aluminium is extending is for the manufacture of pans, etc., for use in the wax-refining and jam-boiling industries, which have hitherto employed copper vessels for this purpose.



WESTINGHOUSE INSTALLATIONS IN AMERICAN ELECTROLYTIC AND ELECTROMETALLURGICAL WORKS.

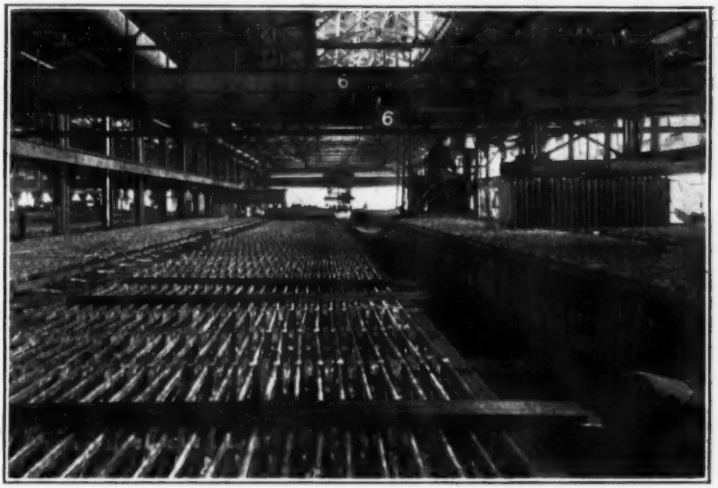
Above, power plant of the Pittsburg Reduction Co., Shawinigan Falls, P. Q., containing four 938-kilowatt 665-volt self-contained shunt generators. Below, plant of the Union Carbide Co., Sault Ste Marie, Mich; twenty-one 375-kilowatt alternators.



PART OF THE ELECTRIC INSTALLATION OF THE PITTSBURG REDUCTION COMPANY, NIAGARA FALLS, N. Y.

General Electric Company's multipolar 2100-kilowatt direct-current generators and rotary converters.

BULLION REFINING.—Electrolytic methods have been applied with great success on both sides of the Atlantic in the refining of gold and silver bullion, the Moebius process being used for silver and the Wohlwill process for gold. In the Moebius process a dilute solution of silver nitrate containing free nitric acid, is employed as electrolyte, while in the Wohlwill process a solution of gold chloride is utilized. In America, the Philadelphia and Denver Mints are equipped with electrolytic parting apparatus, and a similar installation of electrolytic baths is now being erected at the Government mint in San Francisco. Many of the American copper refineries also have



VAT ROOM, AMERICAN METALS REFINING COMPANY.
Crocker-Wheeler electrical equipment.

an electrolytic plant for refining the silver obtained as a by-product in the copper-refining process. In Europe, electrolytic refining is carried on at Frankfort by the Deutsche Gold-und Silber-Scheide Anstalt, and by the Norddeutsche Affinerie at Hamburg, details of the Wohlwill gold-refining process having been worked out at the latter refinery. Electrolytic bullion-refining is also carried out in Great Britain and in France, but no details of the works are available for publication. A recent improvement of the Moebius process is the use of gelatine, which gives a smooth coherent, in place of a rough crystalline deposit at the cathode.

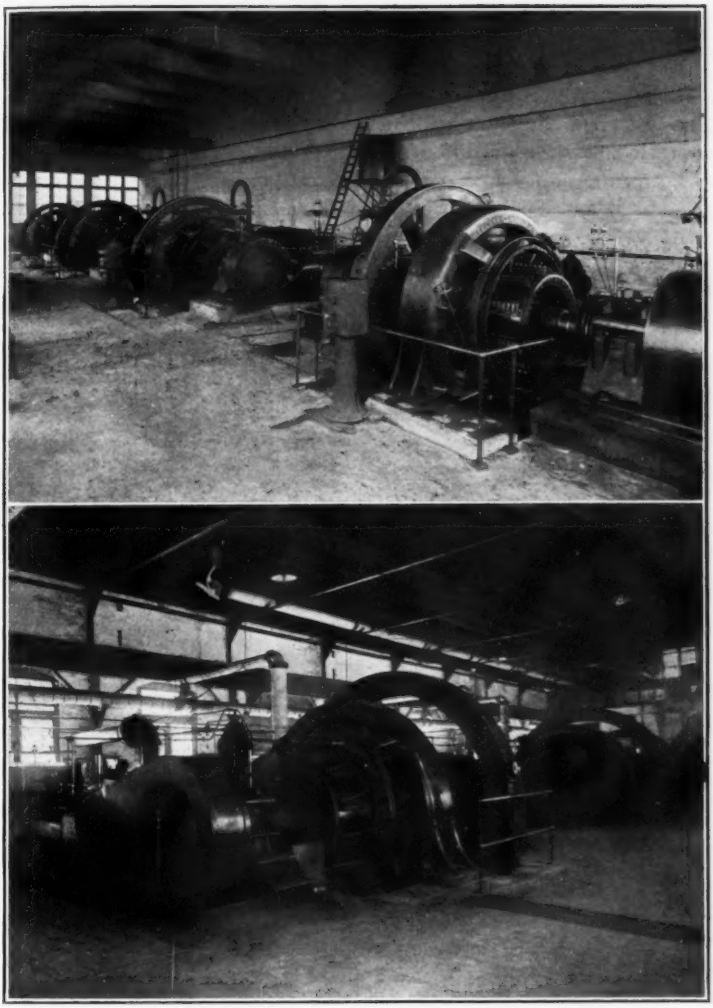
CALCIUM CARBIDE AND ACETYLENE.—Calcium carbide is obtained by heating lime and coke in an electric furnace, and it was first produced in a large scale by Willson at Spray in the United States in

the year 1893. The late Henri Moisson about the same time produced this compound in his laboratory in Paris, and the European patents granted to Willson have not been upheld, owing to the earlier publication of the results of Moisson's chemical researches upon the electric-furnace and its products in the *"Comptes Rendus"* of 1894.

TRANSFORMER PLANT AT UNION CARBIDE WORKS, NIAGARA FALLS.
General Electric Company's 25-cycle 1,870-kilowatt 11,000-2,200 volt transformers.

The early history of the calcium-carbide and acetylene industries is chiefly a record of reckless finance, worthless patents having been used for company flotations upon a large scale, with serious results for the investors and for the industry. The period culminated in 1899-1900, with a series of failures and financial "reconstructions." Since that year, the companies have been slowly recovering from the effects of this unwise boom. Though acetylene gas has not displaced other illuminants to the extent that was at one time expected, it is now used for various purposes much more widely than is generally recognized, and central acetylene-generating stations are found in very many small village communities in Europe and America.

According to the most recent estimates there are now between sixty and seventy works engaged in the production of calcium carbide, and the aggregate production amounts to between 90,000 and 100,000 tons per annum, valued at £1,000,000. The United States, Italy, and France head the list of producing countries, and are also



GENERATING PLANT IN AMERICAN ELECTRO-METALLURGICAL WORKS.

Above, the Orford Copper Co., Bayonne, N. J.; four Crocker-Wheeler generators, 300-kilowatts, 125 volts, 150 revolutions. Mesta Machine Works engines. Below, the American Smelting & Refining Co., Maurer, N. J.; two Crocker-Wheeler generators, 520-kilowatt, 125-volts, 110 revolutions; Hooven-Owens-Rentschler engines.

the largest consumers of carbide for acetylene-generation purposes. During the period of inflated finance, several works for the manufacture of carbide were started in the United Kingdom. All of these have ceased operating, and only one small works is now active, at Askeaton in Ireland. The greater portion of the carbide consumed in the United Kingdom is therefore imported from Norway, and from other countries which produce in excess of their requirements. In France, the industry is controlled by a syndicate with headquarters in Paris, and this exercises a close watch over output and price. Eleven works are reported to be still operating, situated around the following centres of cheap water power:—Bellegarde, Grenoble, Nice and Toulouse. The estimated output of these works in 1906 was 24,000 tons; the annual consumption in France is about 15,000 tons.

Germany is dependent upon Switzerland, Austria, and Norway for two-thirds of its supply of carbide, only 8,000 tons being produced at home whilst 16,000 tons are imported. In the United States, the production of carbide is estimated to amount to 25,000 tons per annum, the Union Carbide Co., with works at Niagara Falls, being the chief producers. A large new factory designed for the utilization of 10,000 horse power is now being erected, however, in a new centre in the States.

Although calcium carbide is being employed chiefly for generating acetylene for illuminating purposes, its application for production of "calcium cyanamide" is likely to lead to developments of some importance. The use of acetylene gas in the oxy-acetylene blow pipe, for the autogenous welding of metals, is another application of considerable industrial importance, since temperatures can be obtained with this apparatus which approach those of the electric arc, and the size and shape of the flame are more suited for welding purposes.

CALCIUM.—Calcium in the metallic state is one of the latest electro-metallurgical products, the metal being produced by electrolysis of fused calcium chloride and fluoride with a rising cathode, which just touches the surface of the fused electrolyte. This method is adopted to prevent the re-solution in the molten electrolyte of the calcium deposited at the cathode. The temperature of the bath is kept at about 670 degrees C. and the process works most satisfactorily with fresh and neutral calcium chloride. The metal is obtained in the form of an irregular rod, made up of a series of buttons, fused together. The metal is dark grey in color, of specific gravity 1.51.

Calcium is now being manufactured upon a commercial scale by the Elektrochemische Werke at Bitterfeld in Germany, under the Rathenau patents, and is being placed upon the market by the same

firm. The only difficulty in the development of the new manufacture lies in the lack of applications or uses for the metal. It has been suggested that it might be used in place of aluminium, for removing the oxides from steel, but at present aluminium is the cheaper metal. For many other reduction processes, calcium cannot replace sodium, since its affinity for oxygen is not so great. Attempts to form alloys of calcium with copper and other metals have also failed, as one would have expected.

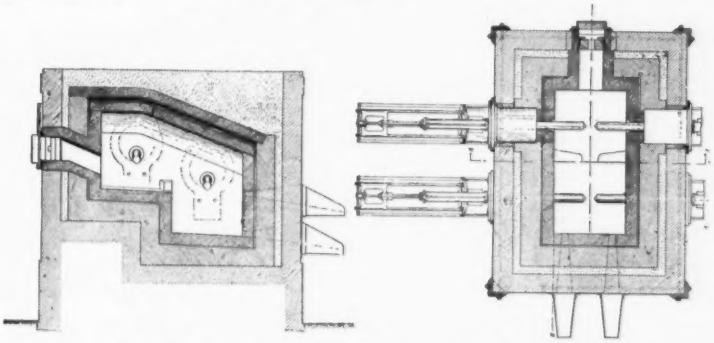
A CARBORUNDUM FURNACE AFTER A RUN.

CARBORUNDUM.—Carborundum is the trade name given to a carbide of silicon—first made by E. G. Acheson at Niagara Falls, by heating coke, sand and sawdust, to a temperature of between 2,000 degrees and 3,000 degrees C. in an electric furnace of the resistance type. The product has the formula SiC, and the manufacture has grown into one of considerable importance on account of the excellent abrasive properties of the carbide. In 1892, 1,000 pounds of carborundum were produced at the Niagara Works, whereas in the last year for which complete figures are available (1906) the output had increased to 6,225,000 pounds. For many years the Niagara Falls works supplied all the demand for this compound.

Another artificial substitute for emery has also appeared, in the form of an electric-furnace product called "*alundum*," obtained by heating bauxite to a high temperature. In order to meet the increased

INTERIOR OF FURNACE ROOM, THE CARBORUNDUM COMPANY, NIAGARA FALLS, N. Y.

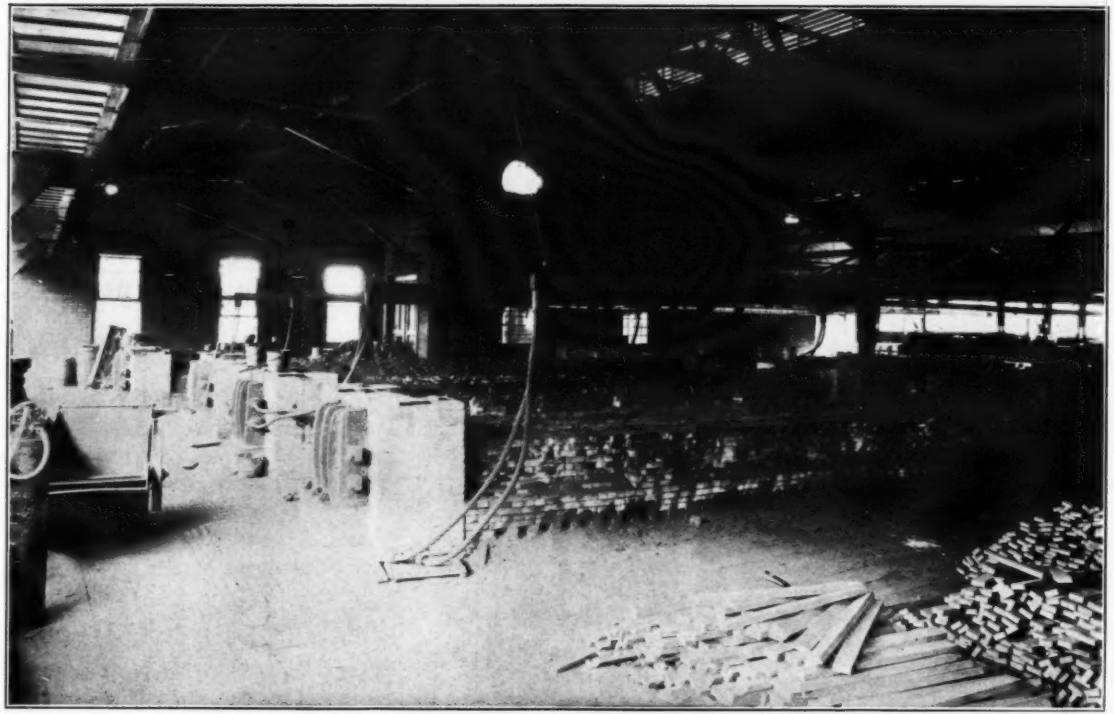
competition, the Carborundum Company of the United States have arranged to carry on the subsidiary manufacture of grinding wheels, abrasive tools, and materials, in Germany, a new works for this purpose having been erected there in 1906.



STASSANO FIXED-TYPE ELECTRIC FURNACE FOR COPPER.

Tucker & Lampen recently have carried out some laboratory experiments with carborundum, and have found that the temperature originally given by Acheson for its formation and dissociation are too high. According to Acheson these temperatures were over 2,500 degrees C., while Tucker and Lampen give 1,600 degrees to 1,900 degrees C., and 2,220 degrees C.

COPPER.—The electrolytic copper-refining industry is the oldest of the electro-metallurgical industries, having been started by James Elkington at Pembrey in South Wales in the year 1869. The process and methods used by Elkington in this small refinery were similar in all respects to those in use at the present day, copper sulphate being employed as the electrolyte with raw-copper anodes and thin sheets of pure copper as cathodes. The only change has been in the magnitude of the operations. At Pembrey the electrolyte was contained in small earthenware pots, and the output was 15 hundred weight per day, or 250 tons per annum. Today there is one refinery in America producing electrolytic copper at the rate of 350 tons per 24 hours, and the aggregate output of all the refineries is estimated at 400,000 tons, or 53 per cent of the total raw-copper production of the world. This enormous growth of the industry has occurred chiefly in recent years, the capacity and output of the American refineries which contribute over 85 per cent of the total having been doubled within the last seven years. The expansion is due partly to the great demand for a very pure copper for electrical purposes, and partly to the presence of silver and gold in the American raw copper, in sufficient amount to



INTERIOR OF FURNACE ROOM, INTERNATIONAL ACHESON GRAPHITE CO., NIAGARA FALLS, N. Y.

The nearer furnace has just been shut off and disconnected and the electrodes are lying in the foreground. The second furnace is in operation.

pay for their recovery from the slimes obtained in the electrolytic process of copper refining. Thirty-four electrolytic refineries are now operating in Europe and America.

The chief progress of recent years in this industry has been in the substitution of machine for hand labour, the casting of the raw-copper anodes, and the charging and discharging of the vats by mechanical methods, now being carried out in all the large and up-to-date refineries. The chief improvement on the chemical side of the process has been the addition of a small amount of hydrochloric acid to the electrolyte in the vats. This, according to Carlson, prevents the loss of silver which otherwise occurs, the insoluble silver chloride being precipitated with the slimes.

DIAMANTINE.—This is a trade name given to a new product obtained by heating alumina with small quantities of silica to a high temperature in the electric furnace. When finely powdered and mixed with clay and water, the new material is said to form a useful wash for the inside lining and walls of furnaces exposed to a high temperature. The new product is being manufactured upon a commercial scale by the Diamantine Werke at Rheinfelden, Germany.

GRAPHITE.—The production of a hard variety of artificial graphite has been carried on since 1892 by Acheson at Niagara Falls. The method of manufacture is to form first a carbide in the electric furnace, and then to decompose it by increasing the heat up to a point at which it dissociates and the second element is volatilized. Under these conditions the carbon remains in the furnace in the form of graphite. Acheson in his earlier work used coke mixed with silica or sand, but he has since found that it is simply necessary to start with ordinary anthracite coal; the impurities of this suffice to provide the second element of the carbide, and when raised to a definite temperature, these elements volatilize and leave the carbon as graphite. The manufacture has been a very successful one, and the works of the International Acheson Graphite Company at Niagara Falls now utilize 2,000 horse power, and produce over 2,000 tons of artificial graphite per annum. The greater portion of this output is used for electro-chemical and electro-metallurgical work, the Acheson artificial graphite having been found specially suited for electrodes. During 1906 Acheson discovered a process by which the soft variety of graphite can be produced in the electric furnace, and it is expected that this new artificial graphite will become a keen competitor of the natural variety, especially as it shews more uniformity of composition. No details of the new process of manufacture have yet been published.

STEAM PRODUCTION FROM THE CHEAPER GRADES OF ANTHRACITE.

By William D. Ennis.

Mr. Ennis in the following pages pursues a discussion of strong practical interest to the coal miner, although it is primarily intended to appeal to the power user. The present subject follows logically as a development of "economy in burning fuel under the steam boiler," which he treated in our June, July and August issues. This particular phase—the burning of the small and cheap grades of anthracite—will be carried to its conclusion next month, and later we shall present another review by Mr. Ennis dealing with the burning of powdered fuels.—THE EDITORS.

AT a large market, say like New York, the price of coal is made up of two elements—the f. o. b. mine cost, and the freight. The latter is a large proportion—sometimes the larger proportion—of the whole. The freight rate is uniform for all qualities of coal. If the price of coal at the mine were fixed in strict proportion to the heating value, there would therefore be a loss to the consumer in buying the cheaper coal, because the reduction in price, proportionate to the reduction in quality, applies to a portion only of the elements making up the price. The logical outcome of resorting to cheap fuel under such conditions would be that the purchaser would eventually receive incombustible dirt, for which he would pay the miner nothing, but for which the railroad would receive its usual freight revenue. Obviously, therefore, for cheap fuel to be attractive, outside of the coal mining regions, either the freight rate must be reduced as the quality is reduced, or the price f. o. b. mines must be reduced more rapidly than the quality. The former outcome seems scarcely probable; the latter condition already exists, and for this reason the burning of the cheaper grades of anthracite is found highly profitable by steam producers who possess the necessary equipment for using such fuel.

Anthracite coal in sizes larger than pea is seldom used for steam production. Here again there enters a price variation which is out of alignment with quality variation. The actual heat units per pound are very little less (not over 5 per cent.) with good pea coal than with egg; but the domestic demand for the larger size, and its comparatively slight advantage to the steam producer, make the price of the latter grade of coal entirely out of line with that of pea.

The fine sizes—from pea down—are the coals to be considered in the present article. For the reason stated, they will not be compared with larger sizes of anthracite, but rather with their actual competitors—bituminous run-of-mine and slack. Run-of-mine coal has been stated to be about 30 per cent less economical than No. 2 buckwheat at present New York prices. The actual figures are: Run-of-mine, price $2.98 per ton. B. T. U. per pound = 14,100; whence for one dollar, the B. T. U. obtained = 9,450,000. A mixture of rice and barley coal containing 12,400 B. T. U. per pound cost $1.82½ per ton, giving 13,650,000 B. T. U. for one dollar. A sample of rice coal costing $2.00 per ton gave 12,457 B. T. U. per pound, or 12,457,000 for a dollar. Barley coal costing $1.65 tested 11,906 B. T. U. per pound, or 14,450,000 for one dollar. These prices are f. o. b. dock, and do not include lighterage or team delivery. The cost of lighterage and team delivery to city buildings is from 60 to 75 cents per ton. Like freight, these are fixed expenses, independent of the quality of fuel. The relative values of the various coals should therefore be based on the f. o. b. dock prices, as given. The following table gives the results in brief:

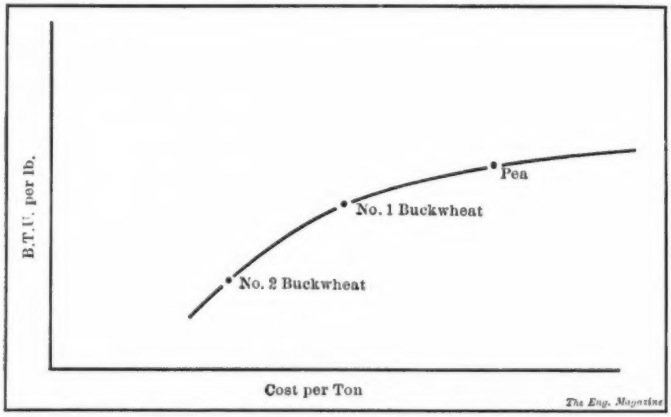
NEW YORK MARKET COAL PRICES—1907.

Grade of Coal.	Price per Ton.	B.T.U. per Dollar.	Saving as Compared with Run-of-Mine.	Saving per Ton, Based on Cost of Run-of-Mine.
Run-of-Mine	$2.98	9,450,000	.....	.....
Rice (No. 2 Buck)..	2.00	12,457,000	32 per cent.	$0.95
Barley (No. 3 Buck).	1.65	14,450,000	53 " "	1.58
Rice and Barley.....	1.82½	13,650,000	44 " "	1.31

It is evident, from the above, that the estimated saving of 30 per cent by burning buckwheat as preferred to run-of-mine is sufficiently conservative, even when some deduction is made from the above figures to cover the cost of providing the necessary draft. The same condition applies in other markets. In Boston, for example, samples of hard and soft coal tested, respectively, hard (No. 2, buckwheat) 11,650, B. T. U.; soft (run-of-mine) 14,547 B. T. U. The prices were $2.34 and $3.37 f. o. b. cars, respectively, corresponding to 10,000,000 B. T. U. and 8,600,000 B. T. U. for one dollar; the saving by using the hard coal amounting to 16.3 per cent, or 55 cents per ton on the price of soft coal. This was with a hard coal of evidently inferior grade.

If it be objected that we should properly compare prices of the cheaper grades of hard coal with those of slack, rather than run-of-mine, it should be remembered that the slack ranges much lower in heating value than the run-of-mine; two recent samples of slack cor-

responding to the $2.98 run-of-mine above mentioned, analyzed 12,-169 B. T. U. The cost was $2.45 per ton, so that the slack is far more expensive, in proportion to heating value, than even the No. 2 buckwheat size of hard coal. Further, the slack is apt to produce much more complaint on account of smoke, and as ordinarily fired will generate at least 20 per cent less useful heat in proportion to its heating value, than will the hard coal.



COMPARATIVE MONEY AND THERMAL VALUES OF VARIOUS GRADES OF COAL.

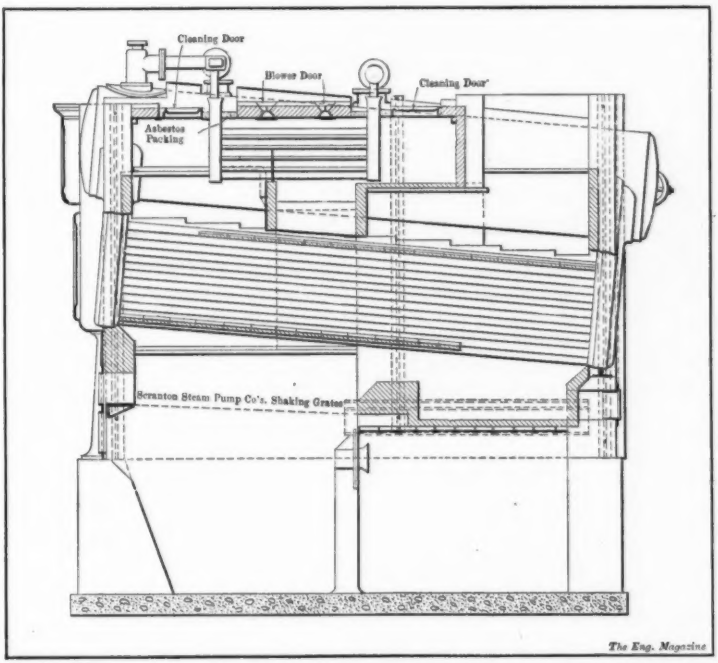
There is only one "size" of slack, and only one grade, excepting as fate interposes. The manufacturer can either burn it or let it alone. With the cheaper hard coals, there is quite a range to choose from; so that it is quite possible that if one grade cannot be used, another can. The following are the sizes below "nut" usually marketed, with the common designation for each:—

SIZES OF HARD COAL—EASTERN MARKETS.

Sizes.	Limits.	Trade Name.
Pea.....	7/8 to 9/16 inch	.....
No. 1 Buckwheat.....	9/16 to 3/8 inch	"Buckwheat."
No. 2 Buckwheat.....	3/8 to 3/16 inch	"Rice."
.....	5/16 to 1/8 inch	"Birdseye."
No. 3 Buckwheat.....	3/16 to 2/32 inch	"Barley."
Culm.....	.....	.....

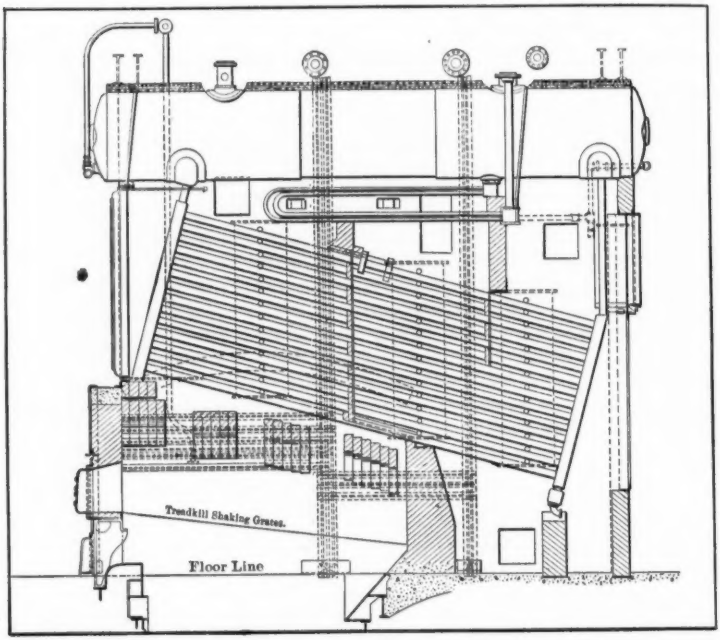
The point has already been made that the tidewater prices of coals decrease with reduction of quality, but more rapidly than the quality decreases. The same rule applies, not only as between, say, egg and pea coal, but also as between the various inferior coals listed in the table. Thus, No. 2 buckwheat costs possibly 35 cents per ton more than the No. 3; but No. 1 buckwheat costs 50 to 60 cents per

ton more than No. 2, and pea, 60 to 75 cents more than No. 1. There is nothing like such a difference in the quality, which makes it all the more noticeable that the slightly better grades not only each command a markedly higher price, but that the augmentation of price itself increases. A representation of this is shown in the chart opposite, which might be interpreted, roughly, by saying, that the better grades of coal command "fancy prices." Those who do not wish to pay "fancy prices" will therefore burn the cheap coals, and in all cases, the cheapest of all the sizes that can be burned will give the largest useful amount of heat for dollar expended. The grade selected must, however, be one that is sufficiently high in heating value and uniform in quality to permit of keeping up the necessary pressure of steam. Culm, it is safe to say, simply cannot be burned unless mixed with at least an equal weight of buckwheat; and not then, unless fresh-mined. It is only about 30 cents per ton cheaper than No. 3 buckwheat, and little if any of it is ever shipped to tidewater *as culm*. Some of it ap-



SETTING FOR 316 HORSE-POWER HEINE BOILER FOR BURNING ANTHRACITE-CULM, SUBURBAN ELECTRIC LIGHT CO., SCRANTON, PA.

parently comes through at times, intermixed with the various grades of buckwheat and pea coal.



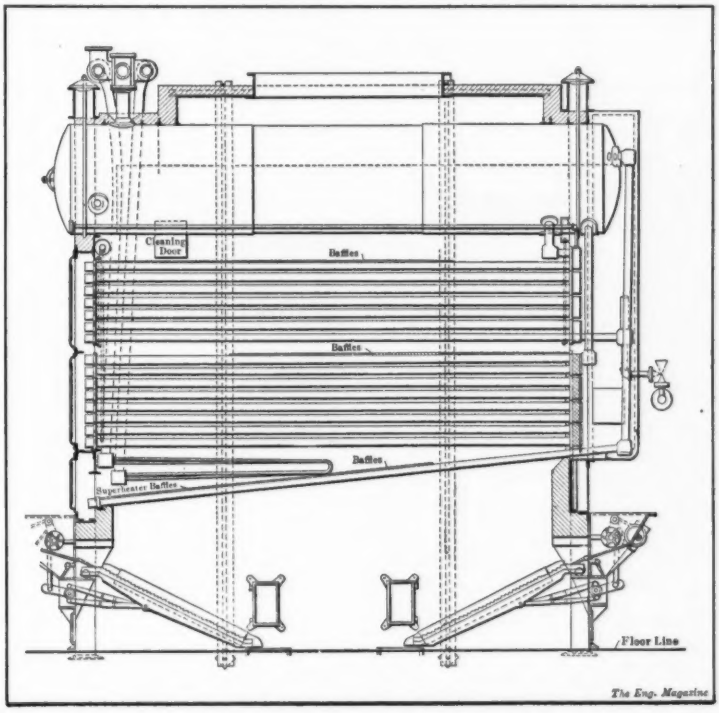
SECTIONAL ELEVATION OF SETTING FOR BABCOCK & WILCOX 650 HORSE-POWER BOILER FOR BURNING NO. 3 BUCKWHEAT COAL, WATERSIDE STATION OF N. Y. EDISON CO.

Equipped with Webster furnaces, the patents for which are owned by the Babcock & Wilcox Co.; with hand firing and moderate ash-pit pressure, 30 to 35 lb. buckwheat coal can be burned per hour per square foot of grate surface. The grates are 12 feet deep.

The finer sizes of anthracite differ to some extent, from the larger sizes in chemical composition. They carry a much larger percentage of sulphur, in the form of iron pyrites. This sulphur results in some loss of heating value, since the heat of combustion of sulphur burned to SO_2 is only about 4,000 B. T. U., as against 14,500 B. T. U. for carbon burned to CO_2. A far more serious disadvantage due to the larger sulphur content is that this substance exerts a detrimental influence on grates and even on boiler surfaces, producing rapid corrosion. It also greatly increases the tendency to clinker, always noticeable with low-grade fuels.

These cheaper coals also naturally run higher in percentage of ash. This is of detriment, not merely in proportion to the actual percentage contained, but in considerably higher proportion. That is, a coal con-

taining 20 per cent of ash is considerably more than 10 per cent less valuable than one containing only 10 per cent of ash, other things being equal. A series of boiler tests demonstrating this point was reported by W. L. Abbott in the *Electrical Age,* November, 1906. These tests showed a gradually decreasing rate of evaporation from the boiler as the percentage of ash increased, until finally when the coal reached that point of inferiority where the ash amounted to 40 per cent, no evaporation whatever was obtained. This must have been due, of course, to the impossibility of keeping the fire in shape, as even 60 per cent of the total heating value of the coal would give more available heat than would be necessarily dissipated by radiation, incomplete combustion, etc. One way of looking at this therefore unexpected result is this: that the efficiency of the boiler, based on combustible, was 40 per cent; consequently, when the 40 per cent of maximum heat transmitted to the steam was just balanced by the 40 per cent less

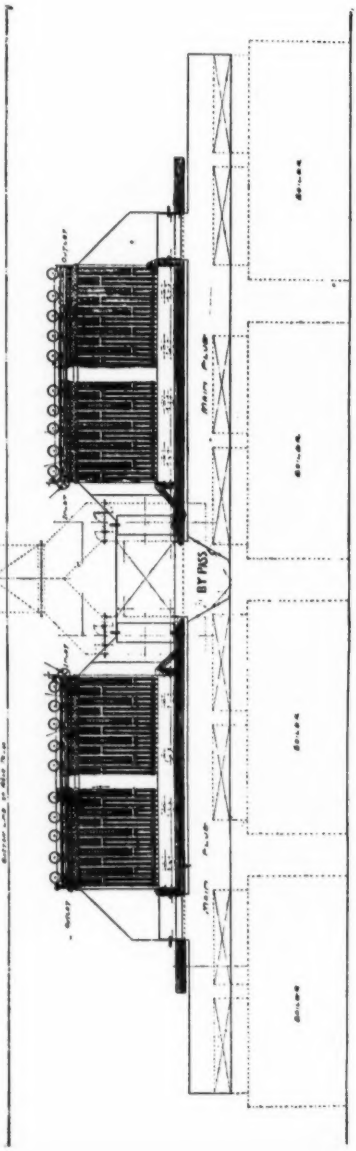


SETTING FOR 700 HORSE-POWER PARKER BOILER FOR BURNING SMALL ANTHRACITE, WYOMING AVENUE POWER PLANT OF PHILADELPHIA RAPID TRANSIT CO.

heating value of the coal, due to that percentage of ash, the evaporation became *nil.*

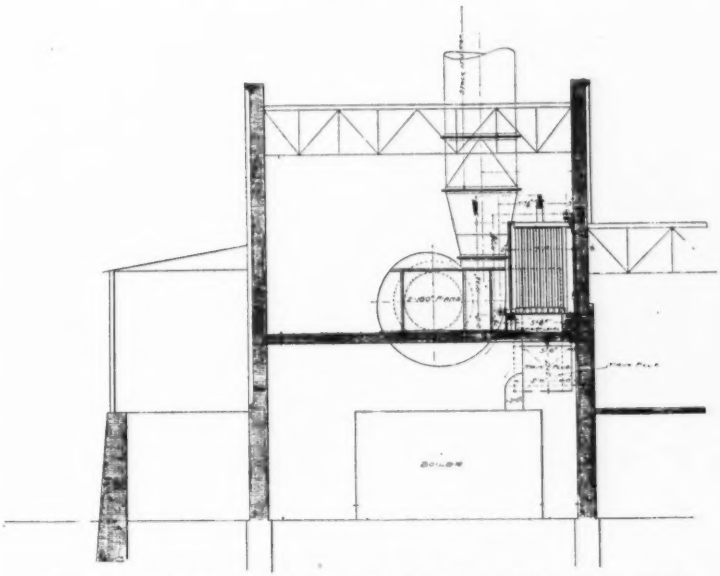
The high percentage of ash necessitates carrying the fires thinner and cleaning them oftener. The frequent breaking up of the fire results in a high loss of fuel to the ash pit. This loss would be high in any case, on account of the fineness of the coal, which not only sifts through ordinary grate bars, like sand, but frequently fuses and runs like a liquid, with the fused ash, under forced draft. The Report of the Pennsylvania State Commission on "Waste of Coal Mining," 1883, mentions* analyses of ash from ash pits of boilers burning culm, in which as much as 58 per cent of carbon was found. If this culm contained (by analysis) 25 per cent of ash to start with, the loss of heating value due to the presence of unconsumed carbon in the ash was 14½ per cent. This loss, with ordinary fuels and firing, is from 1 to 2 per cent.

The percentage of ash in low-grade anthracite coals such as are used at tide-water points is seldom as



PLAN FOR POWER PLANT OF D., L. & W. R. R., HOBOKEN STATION.
Green fuel economizers and mechanical draft, for burning small anthracite.

* Quoted by Professor Kent, "Steam Boiler Economy," First Edition, p. 149.



SECTIONAL ELEVATION OF GREEN FUEL ECONOMIZER INSTALLATION WITH MECHANICAL DRAFT, D., L. & W. R. R., HOBOKEN STATION.

high as 25. The following list gives the ash content of various coals sampled at New York during the past year:

PERCENTAGES OF ASH IN SCREENED COAL.

Kind of Coal.	Percentage of Ash.
Mixture of Rice and Barley	17.25
Rice Coal	20.50
Rice Coal	13.81
Barley Coal	16.96
Rice Coal	16.84
For Comparison.	
Mean of two samples of bituminous-slack	18.90
Mean of three samples of bituminous, run-of-mine	7.88
Average of Rice Coal, above figures	17.05

The rice coal seems, therefore, to contain more than twice the ash that the run-of-mine does, and rather less ash than slack. The percentages vary widely, however, barley sometimes containing less ash than rice, and occasionally less even than is found in samples of No. 1 buckwheat. The ash can of course be decreased by careful washing and screening; but where the coal is billed to the customer at the weight determined immediately after washing, he does not gain much.

The difficulty arising from high percentages of ash is purely mechanical. The heat is there, in close proportion to the percentage of combustible; the thing is to get it out. It is hard to do this, because

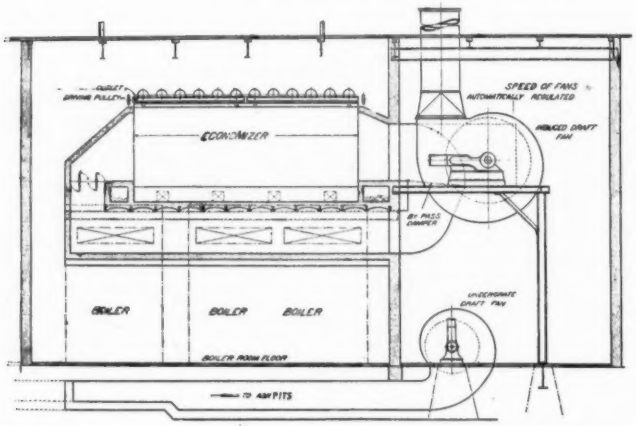
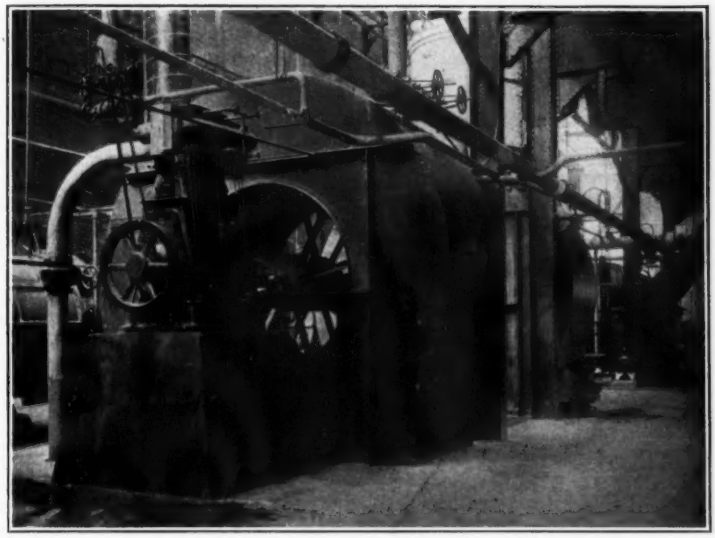


DIAGRAM OF TYPICAL MECHANICAL DRAFT SYSTEM WITH COMBINED FORCED AND INDUCED DRAFT AND ECONOMIZERS.
The B. F. Sturtevant Co., Boston, Mass

the ash slags into a hard cake that stops the air openings, because the fuel falls unconsumed through the grate bars, and because the fine coal packs so closely on the grate that ordinary draft intensities are insufficient to give the air supply access to it. If by mechanical means we remove these mechanical impediments to combustion, we will have no difficulty in getting steam from fine coals. One method is to pulverize the coal and blow it into the furnace. This gives a fuel much finer than even the most powdery culm; but the combustion secured is easily the most effective that is ever produced from coal. The burning of pulverized coal is a subject for discussion in a later article, but it should be referred to here, as demonstrating that neither mere smallness of bulk nor high percentage of ash necessarily makes a coal unfit for use under steam boilers. Mr. Eckley B. Coxe is quoted as having in 1893 placed the following values upon fine sizes of anthracite, f. o. b. mines:

Chestnut	$2.75	per ton
Pea	1.25	" "
No. 1 Buckwheat	.75	" "
No. 2 Buckwheat	.25	" "
No. 3 Buckwheat	.10	" "

These differences, of course, are sufficient to pay the cost of pulverizing, but the interesting point is that effective combustion of the lower grades can be secured *without* pulverizing. This has already increased the value of the relatively cheaper fuels, and will no doubt still further increase their values. The selling of No. 3 buckwheat

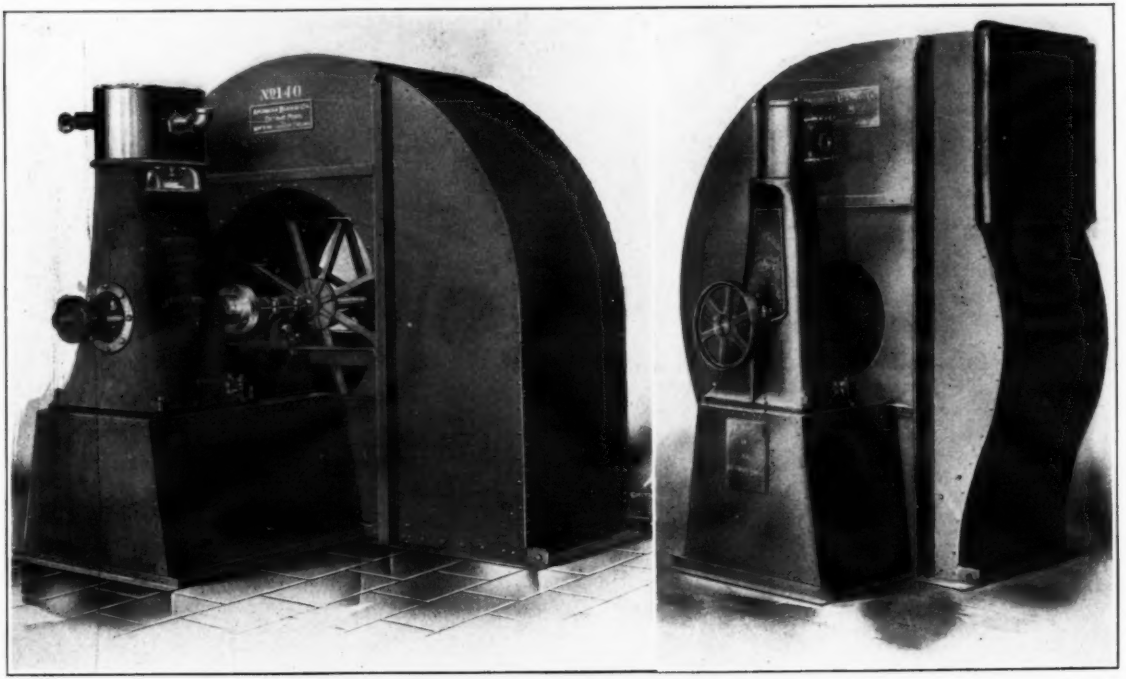


MECHANICAL-DRAFT INSTALLATION, LEHIGH VALLEY R. R. POWER HOUSE, SAYRE, PA.

Two Buffalo Forge Company's blowers with 11-ft. wheels, driven by Buffalo cross-compound enclosed engines. Each fan supplies air for burning 17,000 lb. of coal per hour in 14 boilers, each boiler having 88 sq. ft. of grate surface.

at $1.15 less per ton than pea—a differential of 92 per cent—will soon seem like flagrant economic waste.

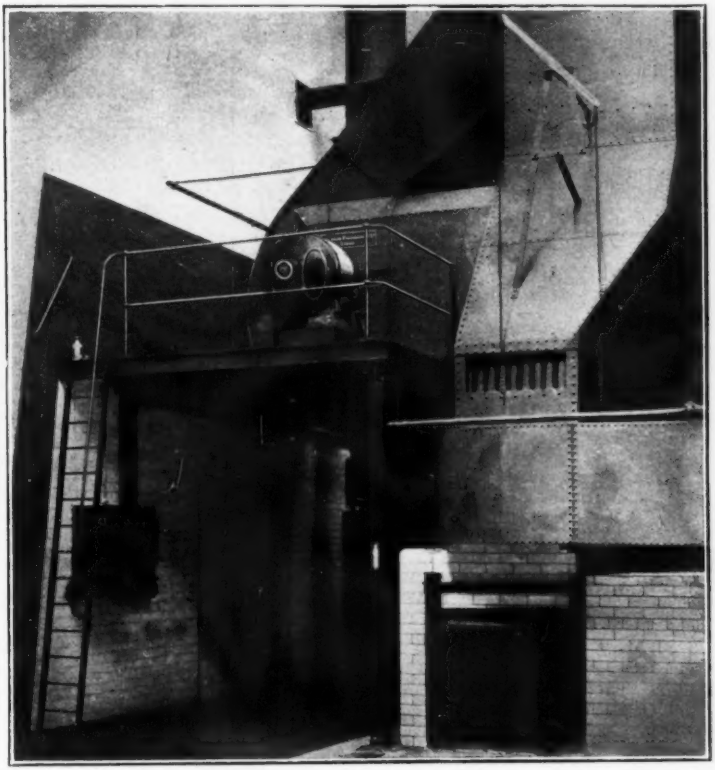
Forced draft in some form is essential to burn fine sizes of anthracite. It is not necessary to go very deeply into mathematics to show that a chimney, considered as a machine, is about the most inefficient machine on earth. If the area of the chimney in square feet, be called A, and the height in feet H, then for a flue-gas temperature of 500 degrees and an air temperature of 62 degrees, the density inside is .0414 and outside .0761, pounds per foot. The difference in weight of gas inside and outside the chimney is then $A \times H \times (.00761 - .0414) = .0347\ AH$. The pressure per square foot is .0347 H, and the height of air column necessary to produce this pressure $= .0347\ H \div .0761 = .456\ H$. The velocity of air corresponding to this height is $\sqrt{2g \times .456\ H} = 5.425\sqrt{H}$, feet per second. The weight passing through the chimney per second $= 5.425\sqrt{H} \times A \times .0761 = .413A\sqrt{H}$. The heat expended in warming this air from 62 to 500 degrees $= (500 - 62)\ .2375 \times .413A\sqrt{H} = 43.A\sqrt{H}$ B. T. U. $=$ $33{,}400\ A\sqrt{H}$ foot pounds. The work done in producing draft is equal to the difference in pressure, inside and outside, multiplied by



TYPICAL MECHANICAL DRAFT INSTALLATIONS BY THE AMERICAN BLOWER CO., DETROIT, MICH.

On the left, a full-housed bottom-discharge fan with direct connected two-cylinder double-acting self-oiling engine. On the right, a top horizontal-discharge fan with single-cylinder self-oiling engine.

the velocity of the air in feet per second, or $.0347\ AH \times 5.425\sqrt{H} = .188\ AH^{\frac{3}{2}}$. The efficiency is equal to the work divided by the heat expended, or $.188\ AH^{\frac{3}{2}} \div 33{,}400\ A\sqrt{H} = .00000563\ H$. When friction and radiation losses are considered, the efficiency is even lower than this. For any reasonable height of chimney not exceeding 300 feet, the efficiency cannot, therefore, exceed one-sixth of one per cent. The useful work obtained is of course the result of energy that is ordinarily wasted. It need not all be wasted, as fuel economizers may be made to absorb one-half of it; but under proper regulation of air supply, the loss of heat to the chimney is so small that it is rarely that any profit can be seen in economizers; and in ninety-nine per cent of all power plants in the United States, at least, the low effi-



ELECTRICALLY DRIVEN INDUCED-DRAFT APPARATUS, SHEFFIELD CORPORATION ELECTRIC POWER STATION.

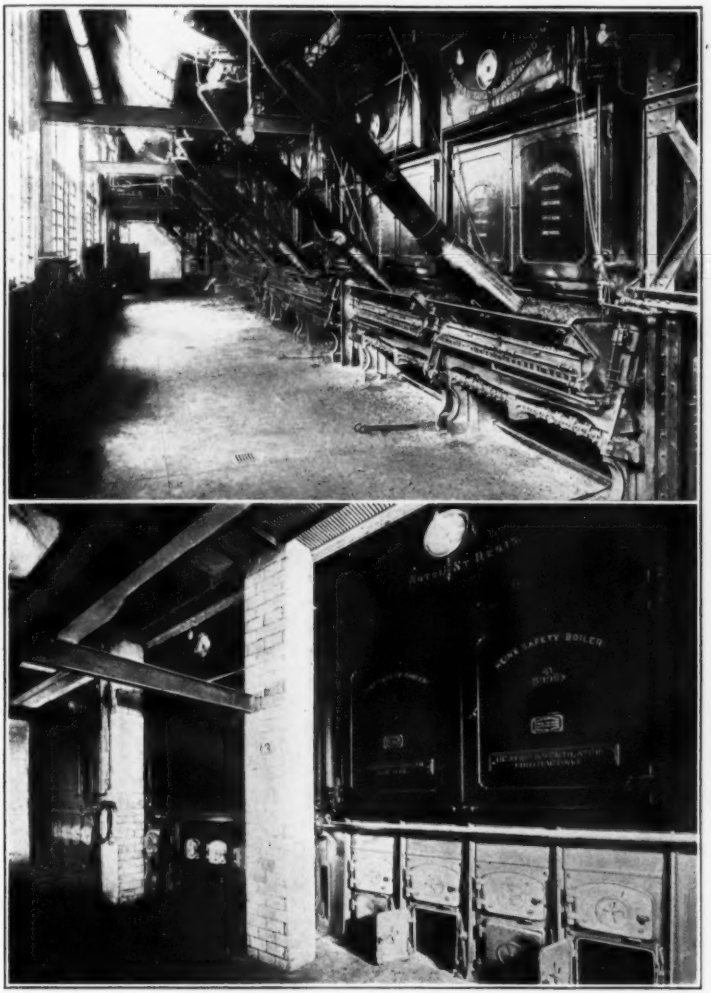
B. F. Sturtevant Co., Boston, Mass.

ciency of the chimney for draft production is scarcely recognized as a disadvantage.

The cost is, however, a serious disadvantage. Brick chimneys used to be figured to cost $5 to $6 per boiler horse power equivalent to the combustion of 5 pounds of coal per hour. This was, however, for reasonably good coals, such as would ordinarily burn when subjected to a draft intensity of ⅜ to ⅝ inches of water. For such coals as we are considering, draft of at least 1 inch should be provided, and much more draft than this will be necessary unless the rate of combustion is to be very low. As the draft intensity from a chimney varies as the square root of the height of the chimney, it is easy to see that when we double or triple the necessary amount of draft we arrive at chimney heights beyond the limits of possible practice.

INDUCED-DRAFT APPARATUS AT ERIE RAILROAD SHOPS, SUSQUEHANNA, PA.
Buffalo Forge Company's 7-ft. fan for two 400 horse-power B. & W. boilers carrying 125-lb. pressure. An example of an induced-draft installation in close quarters.

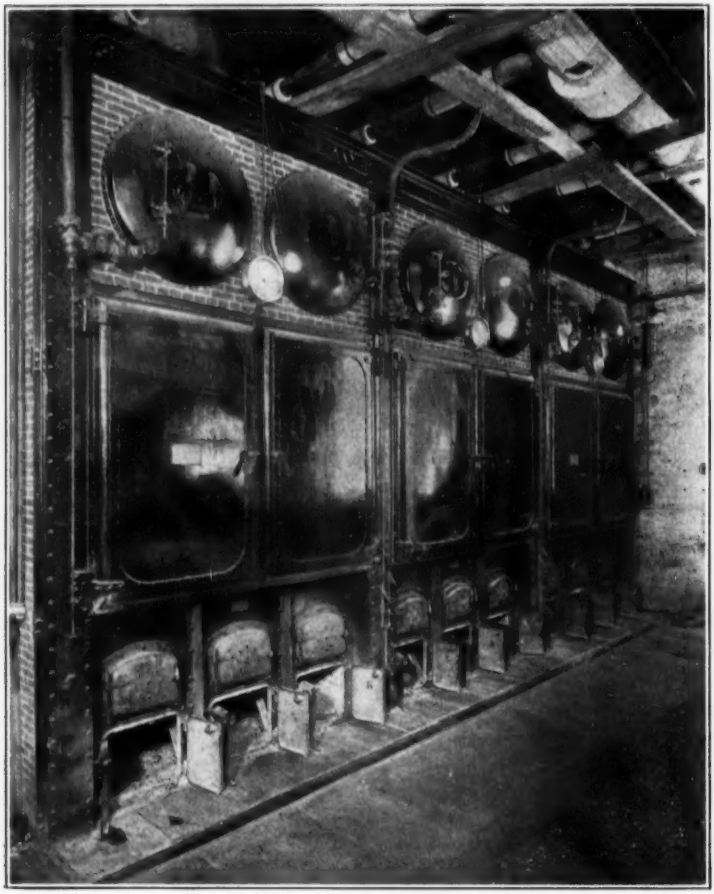
The use of reinforced concrete for chimneys has reduced their cost to about $2 per boiler horse power, but has not made it any more possible to build chimneys from 600 to 1,000 feet high instead of from 80 to 200 feet. Both on account of cost, and on account of physical limitations, chimneys for draft are entirely inadequate, in burning fine sizes of anthracite.



HEINE SAFETY BOILER INSTALLATIONS FOR BURNING RICE COAL.

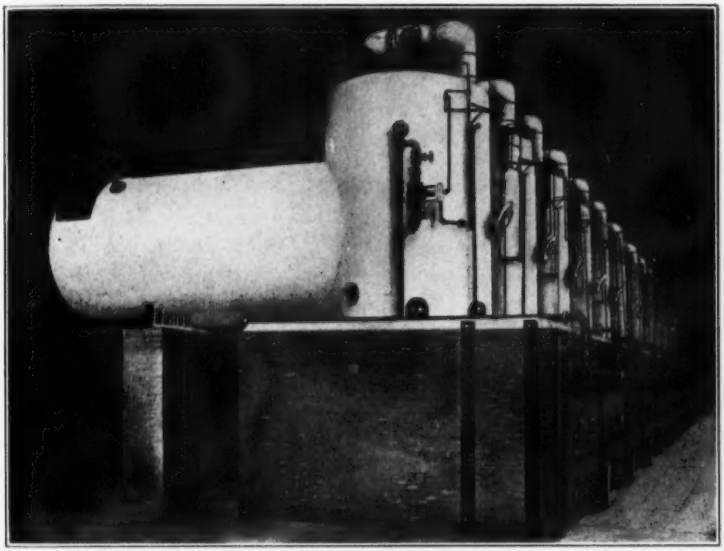
Above, the Federal Sugar Co., Yonkers, N. Y.; twelve 316 horse-power boilers; Wilkinson stokers; economizers and induced-draft fan. Below, the Hotel St. Regis, N. Y.; four 362 horse-power boilers, with 62 sq. ft. dumping grates each. Wing's turbine fans.

A favorite method of providing the high draft required has been to use the steam jet. The only merit possessed by the steam jet, if in this case it can be considered a merit, is that of low cost of installation. In its simplest form, the device may consist of a few pieces of pipe, possibly installed complete at a cost of ten dollars or less, per boiler. With the steam jet, almost any desired intensity of draft can be produced. Clinkers can be kept broken up and smoke so diluted as to be unobjectionable in most instances. The steam consumed

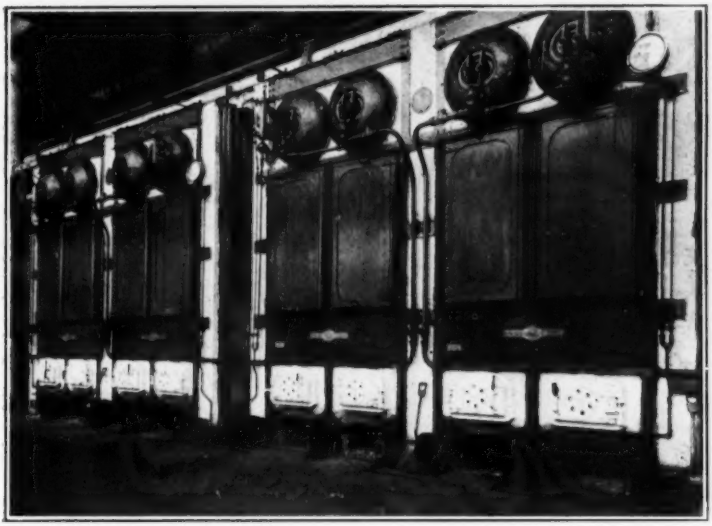


PARKER BOILERS BURNING BUCKWHEAT COAL, POWER PLANT OF THE J. B. STETSON CO., PHILADELPHIA.

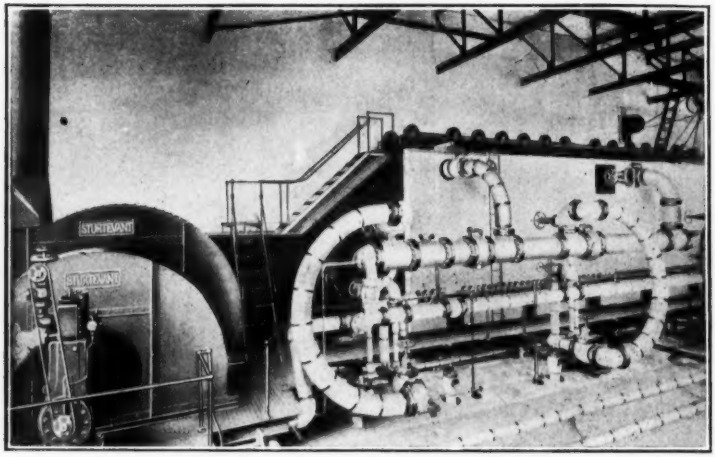
Single-ended boilers of 515 horse-power each. The Parker Boiler Co., Philadelphia.



BATTERY OF TWELVE 250 HORSE-POWER FITZGIBBONS BOILERS BURNING RICE COAL, POWER PLANT OF THE INTERNATIONAL SALT CO., LUDLOWVILLE, N. Y.



AN INSTALLATION OF BABCOCK & WILCOX BOILERS BURNING NO. 3 ANTHRACITE COAL.
Webster patent furnaces, with grates 12-ft. deep; ordinary flush fire fronts.



COMBINED INDUCED-DRAFT AND FORCED-DRAFT APPARATUS AND FUEL ECONOMIZER, B. F. STURTEVANT COMPANY'S POWER PLANT, HYDE PARK, MASS.

by the jet is enormous. The lowest reported tests put it at 8 per cent of the total steam produced; other reports make it as high as 40 per cent. The jet supplies, not air, which is the natural supporter of combustion, but water, which while containing more oxygen in proportion to its weight than air, contains this oxygen *in combination*. The same amount of heat is lost in decomposing the water as is afterwards evolved in burning the fuel with the oxygen thereby set free. The steam jet has been found to increase considerably the percentage of fuel lost in the ash, an always serious item in the case of these fine-sized coals; but what is more important still, even with the practically unlimited draft intensity obtained, the steam jet fails to produce a rate of combustion per square foot of grate per hour equal to that ordinarily obtained by a fan. The breaking up of clinker, which is quite effectively done by the jet, can be accomplished equally well by the use of *exhaust* steam under the grates. Exhaust steam is, in fact, commonly used in connection with many types of stokers, for this very purpose, when burning a clinkering soft coal; and it is beginning to be generally used in the same manner with fine sizes of anthracite, even where fans are employed to produce the necessary intensity of draft.

THE NEW JERSEY PORTAL OF THE PENNSYLVANIA TUNNELS UNDER THE HUDSON RIVER.

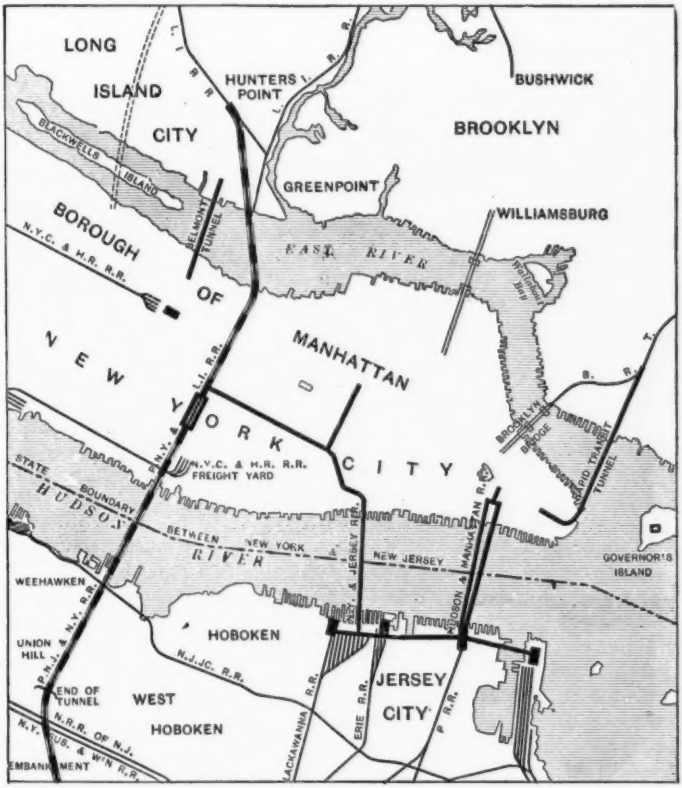
UNDERGROUND WORKINGS IN NEW YORK CITY.

By H. T. Hildage.

In a paper before the Institute of Mining Engineers, Mr. Hildage lately showed the strong analogy between the tunneling operations in and about New York, and practice already familiar to the mining engineer in his own work. This analogy is again suggested by some of the illustrations accompanying this article, but the author's text refers now more especially to work in soft ground and the interesting special methods for its accomplishment. He traces the origin and development of the practice which has found its most conspicuous applications in the several large undertakings now nearly finished under and through Manhattan Island. For the reproduction of the map and of some of the drawings of the shields we are indebted to the courtesy of the American Institute of Mining Engineers.—THE EDITORS.

THE individual undertakings in the construction of tunnels to "emancipate New York City from the limitations of its insular position" have been described in more or less detail, both as regards their design and the methods of construction used. The unparalleled magnitude of the work considered as a whole, the enormous difficulty with which it has been attended, the novelty of the problems in tunnel construction that have been solved, and the almost unbroken success that has attended its execution have been sufficiently demonstrated in various publications. It remains now and it is the purpose of this article to endeavor to discover how the

GENERAL VIEW OF THE OPEN-CUT WORK FOR THE PENNSYLVANIA TUNNEL TERMINAL SITE, 31ST TO 33RD STREETS AND NINTH AVENUE, NEW YORK CITY.



MAP SHOWING TUNNELS UNDER CONSTRUCTION.

work that has just been done is connected with, or is a sequel to, what had been previously accomplished, with a view possibly to obtaining guidance for the future.

There are many steps between the old days of tunnelling, when the only method of temporarily holding the ground was by timbering, when the only means of preventing the flooding of the heading was by pumping, when the "muck" was removed by mule or pony haulage, when the only light was candle or oil light, and when the progress (which was won by dogged perseverance and sheer pluck) was counted in inches per week—and the modern iron-lined tunnel which is clean, well lighted by electricity, equipped with electric traction or mechanical haulage; which is constructed with the aid of a shield fitted with every conceivable device for advancing the work and main-

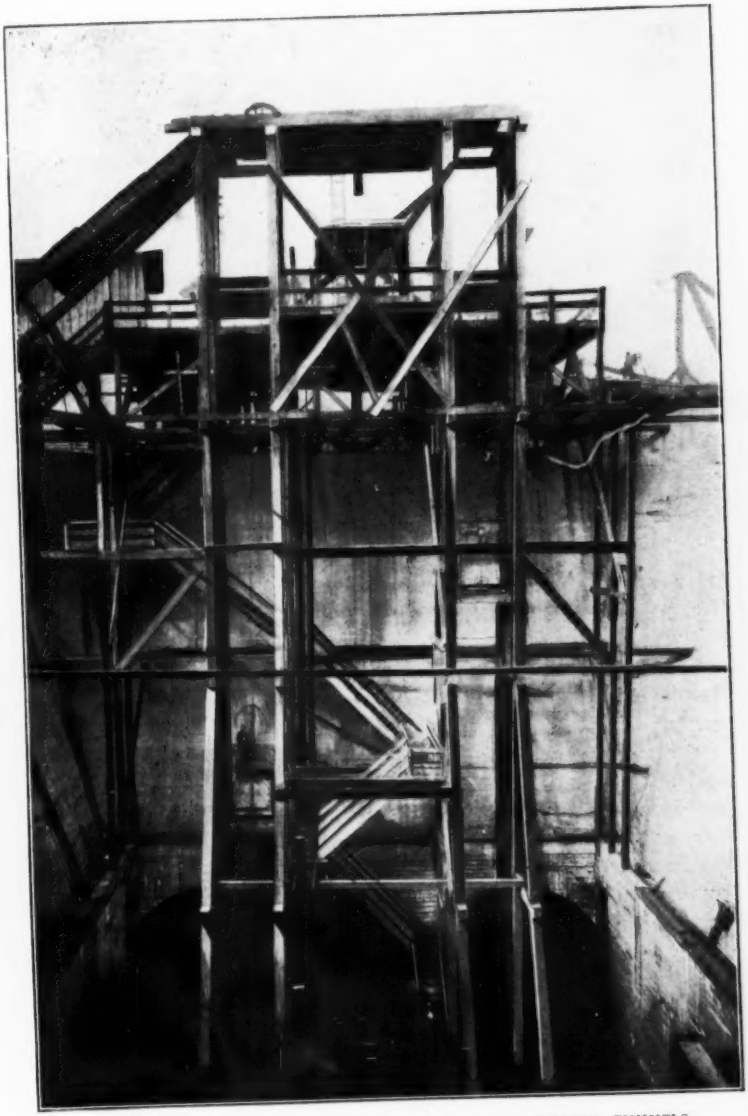
taining the advance, for supporting the ground and protecting the men, and for handling the heavy plates that constitute the tunnel shell; in which progress is steady and can be counted upon and be measured in yards per day.

The first step was taken in the Thames tunnel that was commenced in 1825 by Brunel, who conceived the idea of a shield to support the ground whilst the permanent lining of the tunnel was being built. This shield consisted of a number of small cells with friction rollers between them, each forced forward independently by means of screws. The only thing about this shield that has persisted is the idea. Almost all the completed tunnels in soft ground constructed since have been of circular cross section, and such a tunnel could scarcely be constructed with a shield of Brunel's type.

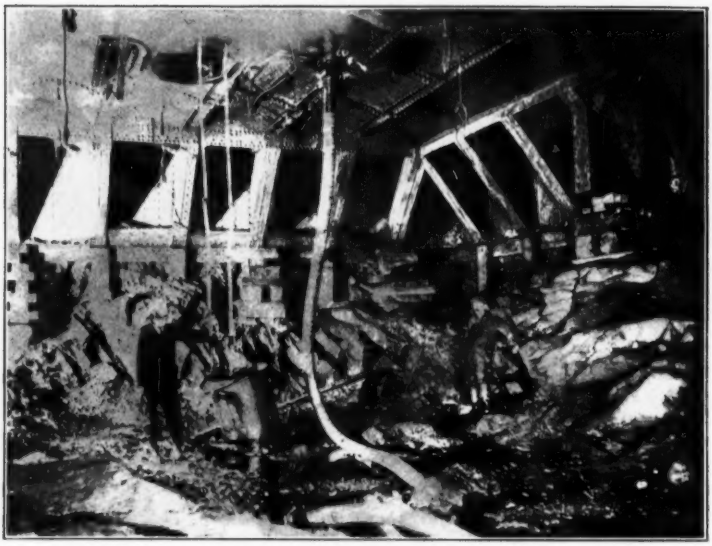
ELECTRIC LOCOMOTIVE IN THE PENNSYLVANIA RAILROAD'S CROSSTOWN TUNNELS.

The great era of development of the art really began with the works of Barlow and Greathead, for the construction of the Thames tunnel must be regarded as a triumph of the splendid personality of Brunel rather than as a success for the shield method.

The first important step in this development was the use of cast-iron lining, and this was taken by Mr. Peter Barlow in the Tower subway in 1869. This tunnel was driven through clay, with the aid



HEADWORKS AT THE WEEHAWKEN SHAFT, PENNSYLVANIA TUNNELS.



THE INTERIOR OF A CAISSON UNDER AIR, SHOWING AIR-TIGHT FLOOR AND CUTTING EDGE.

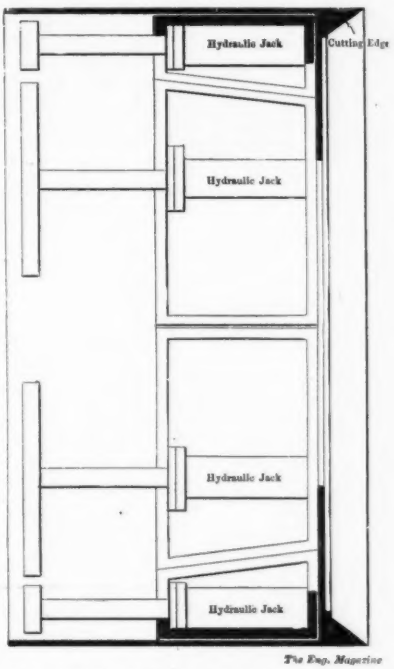
of a cylindrical shield, and the maximum progress made was 9 feet per day of 24 hours. The shield consisted of a single cylinder of wrought-iron plates, ½ inch thick, fitting loosely over the cast-iron lining, stiffened by a cast-iron ring at the forward end to which was bolted a diaphragm. Access to the face was obtained through a rectangular opening in the diaphragm. The shield was advanced by six screw jacks, each 2½ inches in diameter, attached to the shield and abutting against the leading end of the cast-iron lining. The cast-iron lining consisted of rings, 18 inches long and 7 feet 1 inch in external diameter. Each was made up of three segments and a key.

In 1870, a short length of experimental tunnel was driven by means of a shield under Broadway, New York. This tunnel was the first one to be built with a shield that was provided with hydraulic jacks to move it forward. The power for the jacks was supplied by a hand pump attached to the shield, and could be admitted to all or any of the jacks.

The use of compressed air was first suggested by Lord Cochrane who, in 1830, took out a patent for air locks and other appliances to permit its use in shaft-sinking and tunnelling. It was first used, without a shield, in the old Hudson Tunnel, the construction of which was undertaken to afford direct land communication between New

York and the railroad terminals in Jersey City. This tunnel was commenced in 1879, although the sinking of the first shaft in Jersey City was commenced in 1874 and stopped when a depth of 14 feet below mean high water had been reached. When the shaft had been sunk to its full depth, an air-lock was built into the side of the shaft, the excavation was commenced under compressed air, and a chamber was formed that was large enough to start two tunnels from. Each of the tunnels consisted of a very light wrought-iron shell in segments lined with from 2 feet to 2 feet 6 inches of brickwork, making the internal dimensions 16 feet wide and 18 feet high.

The method of working originally used was to excavate a place for a plate and bolt it in before the mud closed in, keeping the top well in advance. This method soon proved too slow and troublesome and the pilot-tunnel method was devised by Mr. J. F. Anderson. A smaller tunnel about 5 feet 6 inches in diameter was driven from 15 to 20 feet ahead of the working face. This tube, made up of wrought-iron plates, was erected one segment at a time, and broad flange plates were bolted in between the segments to give a footing for radial struts. The thin wrought-iron shell of the large tunnel was erected as before and each plate held in position by a radial strut from the pilot tunnel. The brickwork was built inside the wrought-iron shell in lengths of about 10 feet. By these methods about 2,000 feet of the north and 500 feet of the south tunnel had been constructed, and a shaft had been sunk on the New York side and the north tunnel started when the work was suspended in November, 1882, for lack of funds.

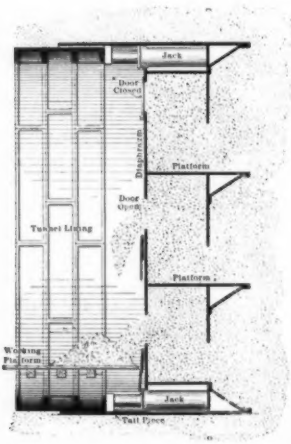


GREATHEAD'S SHIELD FOR CITY & SOUTH LONDON RAILWAY. LONGITUDINAL SECTION.

The next progressive step in the art of tunnelling was made in 1887, when Greathead devised the shield that bears his name and which was used for

tunnelling through London clay, and with compressed air for tunnelling through Thames ballast. This shield (shewn in diagram on page 143) consisted of a steel cylinder stiffened at the forward end with a heavy cast-iron ring built in six segments, to which were attached hydraulic jacks and the cutting edge. To this also was bolted a diaphragm with an opening to the face; in the first shield, this opening was provided with iron doors, working upon rollers; these were subsequently removed and in their place timbers were used that were cut to drop in between channels attached to the diaphragm for the purpose. There were six hydraulic jacks and the rams were provided with large heads to distribute the thrust over the flanges of the cast-iron lining plates. Two hand pumps were provided to supply hydraulic power to these jacks. The rear end of the steel cylinder formed a "tail" under the shelter of which the cast-iron lining plates could be erected.

Tunnelling in Silt and Soft Clay.—Following the construction of the City & South London Railway tunnels, the development of the art has progressed much more rapidly. In the year 1889, the construction of the Hudson Tunnel that had been abandoned seven years previously was recommenced with a shield and cast-iron lining, and the St. Clair River tunnel was commenced and finished thirteen months later. Both of these undertakings marked a distinct advance in shield tunnelling, inasmuch as both tunnels were much larger than any iron-lined tunnel previously built with a cylindrical shield, and the St. Clair shield moreover was the first shield actually used that was provided with an erector, although Greathead designed and had one built in 1876 with a hydraulic erector, for use in the Woolwich subway.



SHIELD USED FOR CONTINUATION OF OLD HUDSON TUNNEL.

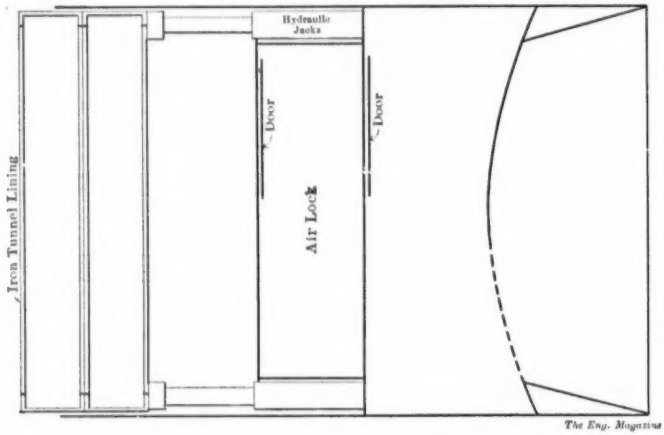
The second period of activity in the history of the Hudson tunnel just referred to as having commenced early in 1889, began when the work in the north tunnel from Jersey City was taken up by S. Pearson & Son of London, who built a shield at the end of the brickwork and commenced to drive an iron-lined tunnel. This shield (as shown here) consisted of a steel shell or skin, 19 feet 11 inches in external diameter, stiffened by the addition of an

inner shell connected to it by radial webs. The compartments of this ring were utilized to hold the sixteen hydraulic jacks for propelling the shield, using the iron lining as an abutment. The interior, shut off from the tunnel by a diaphragm, was divided into nine pockets by two vertical partitions and two horizontal platforms, and these pockets were open to the face and accessible from the tunnel through hinged doors. The method of working then used was to open some of the doors of the shield and to turn power on to the jacks. The shield moved slowly ahead, laying bare as it went the "tail" which had been lying over the outside of the lining, and ultimately giving, when the jacks were returned, space for the erection of another ring. The soft silt squeezed slowly in through the open doors, and falling upon the working platform, was loaded into cars and removed. When the shield had travelled the full length of a ring, the power was shut off, the doors closed, the invert cleaned and the ring erected. This was done by means of a hydraulic erector that trailed behind the shield on rails supported by the iron lining. This erector consisted of an arm revolving on a pivot by two hydraulic jacks and carrying a third hydraulic jack, the ram of which was fitted with a jaw capable of being attached to one of the tunnel segments. The whole arrangement was mounted on a carriage with four wheels. The inside diameter of the cast-iron rings was 19 feet 6 inches and the length about 20 inches. This method of tunnelling proved much more successful than the pilot-tunnel method, and with it Messrs. S. Pearson & Son completed about 1,900 feet of tunnel by July, 1891, when lack of funds again suspended operations.

As far as tunnelling in soft semi-fluid silt or soft clay is concerned, the evolution of the shield was completed when this shield was built. The essentials were an outer skin, the rear part of which covered the iron lining, and the forward part of which served to hold the hydraulic jacks to propel it, and was stiffened by an inner ring of cast iron or steel and cross bracing; some means of partially closing the face and at the same time permitting the flow of material into the tunnel, in the case of soft, flowing material, or of giving more or less free access to the face in the case of material that required to be dug out; in the case of large tunnels, erectors for the purpose of handling the iron lining; and platforms within the shield to enable the whole face to be reached. With the exception of details of more or less importance, no further changes have been made in the construction of shields used exclusively for silt or clay tunnelling. Sliding platforms actuated by hydraulic jacks have been used with profit, but their chief value has been in dealing with other conditions

to be mentioned later. In some large shields such as the shields for station and cross-over tunnels on the City & South London Railway extension, the Waterloo & City Railway and the Baker Street and Waterloo Railway, two erectors have been used instead of one. These shields were really larger editions of Greathead's first shield, with erectors and sliding platforms added.

As shown in the previous description, the method of working varied with the stability of the material; in the London clay, a very stiff clay that stood without measurable flow, a box heading was often driven, but in every case a space was excavated for the shield to be shoved into. In the softer clay, through which the St. Clair tunnel passes, the men worked ahead of the shield to excavate, but apparently the flow was great, for they frequently excavated as much as 50 per cent more clay than was displaced by the length of tunnel built. In the fluid silt of the Hudson River, it was not necessary to excavate at all; the material simply flowed in through the open doors. At a later date, some time after the construction of the Hudson tunnel had been taken up by the present owners and the south tube was being completed, even this was changed; the shield doors were kept closed and very little silt was permitted to enter the tunnel; it was simply shoved out of the way. This method was applied to both the north and south tunnels, and very rapid progress was made in the silt.

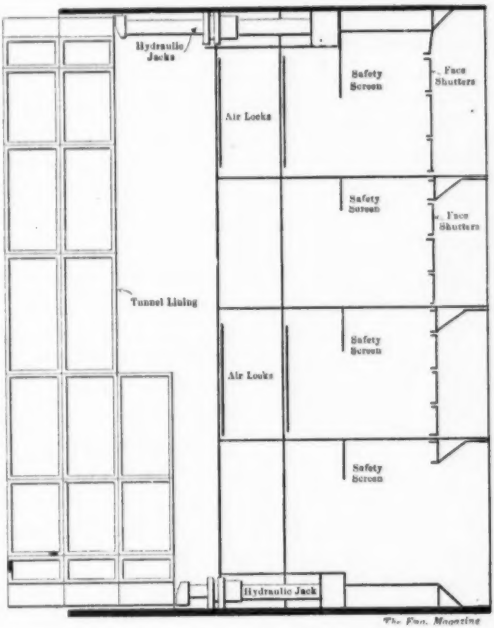


GREATHEAD'S SHIELD FOR THE NORTH WOOLWICH SUBWAY.

When the North River tunnels of the Pennsylvania Railroad Co. were being built, it was found impossible to use this method and at the same time control the shield, maintaining line and grade. It was

necessary to take in part of the silt through the doors in order to keep the shield on grade and to prevent the tunnel from rising considerably immediately after construction.

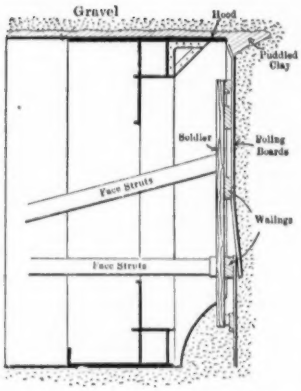
Tunnelling in Open Ground and Gravel.—Practically all the changes and additions that were made to shields since the St. Clair and the Hudson north tunnel shields were built, have been made for the purpose of permitting the ground to be excavated ahead of the shield, when it consisted either of (a) sand or gravel, or (b) rock, overlain by sand, gravel or silt. In both of these cases, for safe, rapid and efficient work it is almost always necessary to maintain a vertical face in front of the shield.



SHIELD FOR BLACKWALL TUNNEL. LONGITUDINAL SECTION.

Probably the first shield especially designed to deal with sand and gravel, was designed and built by Greathead for the North Woolwich Subway already mentioned (page 146), but never used. This shield contained an air lock within its length, and also a siphon-trap arrangement that rendered it possible to prevent the flooding of the tunnel when the face was lost, by maintaining sufficient air pressure.

The shield that was used for the Blackwall tunnel (figured above) designed by Mr. E. W. Moir, (as also was the one used in the Hudson north tunnel), was required to meet a variety of conditions. The forward part of the shield was divided into twelve pockets or compartments by vertical diaphragms and horizontal platforms that gave considerable stiffness to the structure. The face was closed by two plate diaphragms, suitably stiffened, one of which was about the centre of the length of the shield and the other about 3 feet behind it. Four air-locks were provided, so that a higher air pressure could be

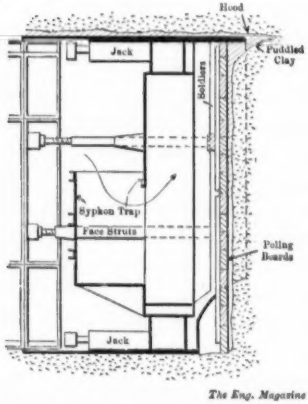


HOODED SHIELD FOR WATERLOO & CITY RAILWAY. READY TO ADVANCE.

used in the face than was in the tunnel, and each pocket was fitted with a chute, fitted with air-tight doors at each end, for the removal of the spoil. In each end of the compartments were hanging curtains or screens, similar to the one in the Greathead shield last mentioned, for the protection of the men in case of a sudden inrush of water.

Two hydraulic erectors were attached to the back of the shield. To the sides of each compartment in the upper three floors were attached guides in which ran sliding shutters controlled by screws for poling the face. In the lower part of the shield, where shutters were not provided, horizontal poling boards were used to hold the face, and these were strutted against the shield with telescopic struts that would shorten under great pressure. When the shield was shoved, the screws controlling the shutters were released by the men as it advanced, and the struts holding the poling in the lower pockets shortened. The position of the face was thus to a certain extent independent of the position or movement of the shield.

Hooded Shield.—In the construction of that part of the Waterloo & City Railway (1894) that was in gravel, the method at first used was the same as that used by Greathead in the same kind of ground and consisted of excavating a timbered length ahead of the shield, into which it could be shoved. After a time this was abandoned and a hooded shield (see figure above), was built and used with much success. The hood in this case was a prolongation of the skin plates round the upper two-thirds of the circumference for some distance beyond the front of the shield. This prolongation forms in the front of the shield a working chamber, under



SHIELD FOR BAKER ST. & WATERLOO RAILWAY.

cover of which the men poling the face can work in safety and need not take care of the roof. It reduced the amount of excavation to the net section of the shield, avoided leaving poling boards in the ground as was done in the City & South London tunnels, and escaped much of the disturbance of the unexcavated ground that necessarily occurred in the Blackwall tunnel, and rendered it possible to remove all the ballast from in front of the cutting edge in the invert.

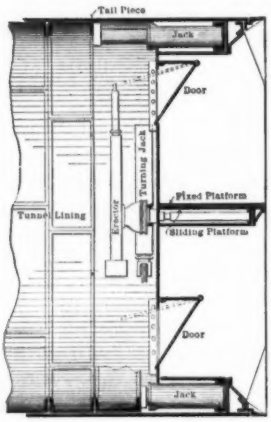
This shield and the method of working it were designed by H. H. Dalrymple-Hay. Pockets were excavated in front of the cutting edge to a distance equal to the advance of the shield and filled with puddled clay. When the shield was shoved ahead, the cutting edge buried itself in the soft clay, and as the work progressed a layer of clay was left outside the skin of the shield and tunnel and reduced the losses of air considerably. This method of working was used in the Baker & Waterloo Railway tunnels in 1900 with some modifications, and in the Morton Street extension of the Hudson tunnel.

Tunnelling in Mixed Ground.—In all the cases so far mentioned, the face worked has consisted either entirely of clay, entirely of sand and gravel, or of clay overlain with sand and gravel. The latter case was probably no more difficult to handle than the second. In the tunnels under the North and East Rivers, however, it has frequently been necessary to work a face consisting partly of rock and partly of silt or quicksand, and special appliances and methods were necessary.

This difficulty was met for the first time in the Hudson north tunnel soon after the work was recommenced in 1901, when it was found that the tunnel would pass through a ridge of rock near the New York shore. A horizontal platform was built projecting about 2 feet in front of the shield and supported by raking struts from below, to carry the roof of the excavation, and all work was carried out under its shelter. That portion of the silt between the rock surface and the platform was held up by poling boards, stretched against the shield, whilst a path for the shield was blasted out below with light charges of dynamite. On account of the position of the shield (it had rolled on its axis about 45 degrees), it was not possible to hold the face whilst the shield was shoved and consequently the pockets became filled with silt each time and had to be cleaned out. Besides rendering the work tedious and slow, this resulted in the denuding of the tunnel of the cover of clay and contributed to the occurrence of blows. The evil was mitigated or avoided by laying a blanket of good clay on the river bed just above the shield, as had been done in the Blackwall tunnel.

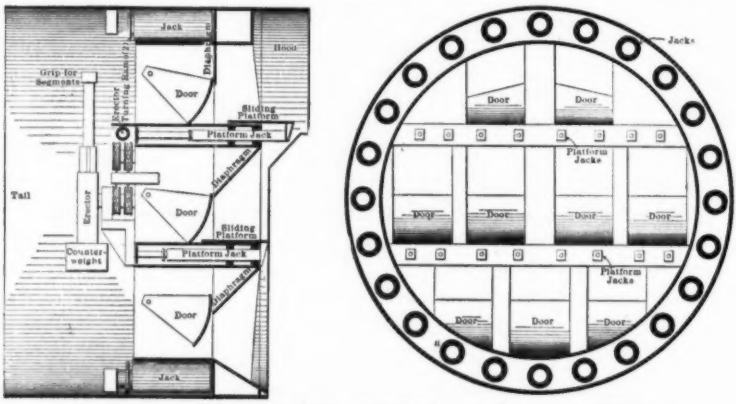
The companion (south) tunnel was smaller in diameter, and being

driven with its crown at the same level as the north tunnel, it was expected that a good deal of the rock work would be avoided. The shield (shown below) was different in some respects. It consisted of an outer skin stiffened by an inner shell. The space inside this shell was divided into compartments or pockets by vertical stiffening partitions and a horizontal platform. The face was closed with a diaphragm which was provided with doors. A horizontal sliding platform in three parts was provided, each part being actuated by two hydraulic jacks. The hydraulic erector was attached to the shield and rotated about an axis coincident with the axis of the shield.



SHIELD USED FOR HUDSON SOUTH TUNNEL.

In the design of the shield for the North River Tunnels of the Pennsylvania Railroad Company, full advantage was taken of the experience in the old Hudson tunnel and in the tunnels through the Thames gravel. This shield was designed chiefly to deal with the difficult ground that it was expected to meet with on both sides of the river, before the shield was entirely in silt. It was expected that as the shield left the rock there would be a face partly rock and partly sand, with the rock line gradually lowering until it disappeared, and then a face partly sand and partly silt until a full face of silt was reached. These conditions were real-



SHIELD USED FOR PENNSYLVANIA COMPANY'S NORTH RIVER TUNNEL.

ized on the New Jersey side, but on the Manhattan side there was practically no sand.

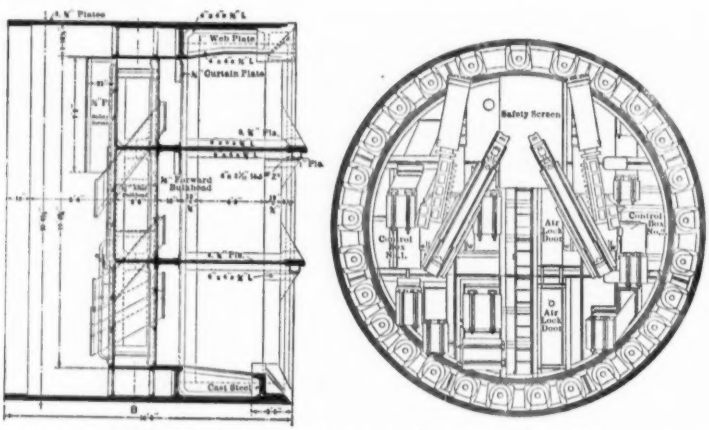
The shields (foot of page 150) had an external diameter of 23 feet 6¼ inches; the internal diameter was 23 feet 2 inches, allowing a clearance of 1 inch all around the tunnel lining, which was 23 feet in external diameter. A hood was attached which covered rather more than one-third of the circumference, and extended 2 feet 3⅜ inches in front of the face. The length of the tail was long enough to cover two and a half rings of the lining, which were 30 inches long. The forward part of the shield was divided into pockets by vertical partitions and horizontal platforms. Each of the platforms had a sliding extension made in four pieces, each piece being actuated by two hydraulic jacks.

The pockets were closed at the end nearest the face by inclined plates covering about half the opening. The remainder of the opening could be closed by means of a door. The doors were segments of a cylinder and swung on pivots attached to a vertical diaghragm. A single erector was used and pivoted at the axis of the shield.

The method of working a face consisting partly of rock and partly of silt was to pole the silt with vertical poling boards and blast out the rock. When the shield was shoved, walings were put against the poling boards and held in place by the sliding platforms and by struts which passed through the shield against the tunnel lining. When the rock line fell entirely below the level of one of the platforms, that part of the silt above the platform was not poled.

In a face that consisted partly of rock and partly of sand, a similar method was used, except that the polings were horizontal instead of vertical. The top board was advanced first and strutted to the shield, and then the second and so on until the whole face was advanced, when the "soldiers" were put against it and held by the sliding platforms and by struts that passed through the shield to the tunnel lining. The ground being rather better than was expected, it was possible to advance the poling boards for a full ring length at one operation, and as the hood was not long enough to permit of this, roof and side polings were necessary.

The shield (see page 152) that is being used for the East River tunnels of the Pennsylvania Railroad Company is very similar to the one that was used in the Blackwall tunnel, the changes that have been made, having no doubt been suggested by the experience there obtained (the contractors for the East River tunnels, S. Pearson & Son, were the contractors for the Blackwall tunnel and Mr. Moir, the managing director, designed also this shield). The



SHIELD FOR PENNSYLVANIA COMPANY'S EAST RIVER TUNNEL.

jacks were more closely spaced around the lower part of the shield than around the upper. The reason for this arrangement, as stated before, is that in a large tunnel it is not always possible to keep the air pressure high enough to keep out the sand and water at the invert without blowing the "cover" off at the roof (where the pressure would be excessive); hence the lower part of the shield is more or less full of sand, and additional power is necessary to displace it.

There is a heavy cast-steel cutting edge around the lower part of the circumference; the need for it has been shewn by many shields being damaged at this point and requiring repairs whilst the work is in progress. The shield is also fitted with a hood not shewn in the diagram, that can be advanced or retracted in segments by means of screws running in bearings attached to the skin and fitted with nuts. Air locks and face shutters are provided as in the Blackwell tunnel, but these have not, so far, been used for their intended purpose.

The method of working is generally similar to that used in other tunnels. The roof and sides are poled in front of the hood and the face is poled down to the level of the lower platform, the lower part of the shield being left practically full of sand; the polings are held up with struts that will telescope under the great pressure that comes upon them when the shield is advanced. With a face of part rock and part sand, the sand is held up by poling boards, whilst the rock is blasted out.

Shields of the Future.—Whilst the beds of the North and East Rivers present greater difficulties to the tunnel builder than the bed of the Thames, chiefly on account of the fact that it is not possible to

build a tunnel under either of them that is wholly in silt and sand, or wholly in rock, without approaching too near the bed of the river in the one case, or going to excessive depths and even then running the risk of meeting unsound rock in the other, and whilst these difficulties have been increased considerably by the fact that the tunnels that have been built in the neighborhood of New York are much larger than the tunnels that have been built under the Thames, with the exception of the Blackwall tunnel and the Rotherhithe tunnel recently constructed, it is evident that the methods that have been successfully used in New York are the same methods that were used in London. Moreover, there is plenty of evidence that these methods were not copied, but were arrived at as a result of experience and a careful study of the conditions met with. It therefore seems that these methods are pretty generally applicable and that it ought now to be possible to construct a shield which will deal efficiently and satisfactorily with any conditions that can be developed in tunnel work.

Several writers have divided shields into three classes according to the character of the material they are designed to tunnel through. Whilst the system of classification thus suggested may be excellent for shields that have been constructed in the past, of which it can probably be truly said that they have all been experimental, it is better to adopt a somewhat different classification for shields to be used in future work.

The first class, as before, would contain shields designed for work with an open face, which would not differ materially from the original Greathead shield for small tunnels and from the Central London Railway and Waterloo & City Railway station tunnel shields, which have movable tables to facilitate working at different levels. The second class would contain shields that could be satisfactorily used where it is known that it will not be necessary to work in front of the shield. Such cases are however so rare and the consequences of adopting an unsuitable design of shield so costly and serious, that this class might well be omitted.

The third class of shield would be used in all cases of soft or loose ground where there was any possibility that work would have to be done in front of the shield; in tunnels that pass through gravel or sands containing boulders or other obstructions; that include in the depth of their cross section the contact between sand or gravel and rock, or silt and rock; and generally in cases where there is any doubt about the nature of the ground to be dealt with. The shields in this class should be fitted with appliances for supporting the unexcavated ground in an undisturbed condition, such as an efficient hood, and in

larger sizes of shields, sliding platforms, with struts for transferring the pressure of the face to the iron lining, or possibly shutters fitted with a satisfactory arrangement for release when the shield is advanced; with safety appliances to facilitate the escape of the men in case of blows or runs of material, such as siphon traps and screens; and if possible, with air locks to permit of a graduated air pressure being used in the face.

The value of the hood was amply demonstrated in the construction of the Waterloo & City and the Baker Street & Waterloo Railways. It has been emphasized in the experience in the North and East River tunnels. It should project so far in front of the shield that it will never be necessary to pole the roof and the sides of the excavation, and should be continued around at least two-thirds of the circumference.

The use of sliding platforms in supporting the face is exemplified only in the case of the Pennsylvania Railroad Company's North River tunnels. They have a further use. If they are advanced immediately after the shove, to their full stroke—that is, until they project as far as the hood—the miners can with care work safely under them as under a hood; in this way the work can be done at each level in the shield at the same time and the time necessary to pole the entire face will be proportionately shortened.

Shutters for supporting the face were used on the Blackwall tunnel, and were provided in the Pennsylvania Company's East River tunnels, but, apparently, they have not so far been used.

It is very desirable, if possible, that the arrangement for poling the face should be an integral part of the shield. There are two difficulties in the way, viz., the necessity for a satisfactory release arrangement that will hold the shutter up to the face with sufficient force to prevent disturbance, and at the same time will release it as the shield is advanced; and the fact that in order to avoid disturbing the ground, the area covered by the shutters should be as nearly as possible equal to the total area of the cross section of the shield.

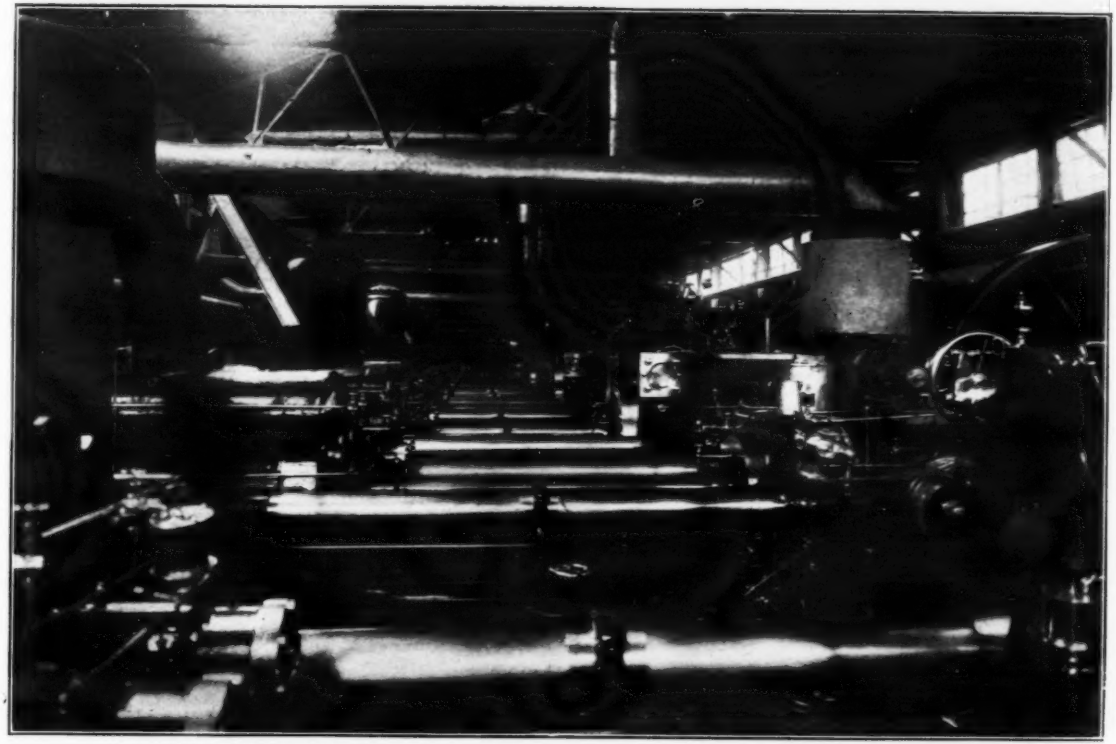
The first difficulty might be overcome by holding the shutters up to the face with hydraulic or compressed-air cylinders suitably fitted with release valves, but in introducing such an arrangement, it is necessary to bear in mind that it will be subjected to very rough usage. Materials and tools used in the construction of tunnels are probably worked more nearly to their breaking point than in any other kind of work and it is undesirable to introduce intricate or delicate mechanism.

The second difficulty is a more serious one. The proper place

PUMPING STATION IN THE BELMONT TUNNEL. THREE CAMERON PUMPS HANDLING 1,000 GALLONS PER MINUTE WITH A LIFT OF 110 FEET.

for shutters is undoubtedly in the hood, but on the other hand, the hood is often subjected to enormous forces and must be made very strong and if necessary stiffened with brackets. Moreover the use of shutters will render it very difficult, if not impossible, to use the clay pocket system, which is of great value.

The siphon traps are very valuable safe-guards in tunnelling through open ground, and can be very readily attached to the door openings of large shields. In the event of a run of material in the face, resulting in temporary loss of air pressure in the tunnel, the water rushes into the shield until its level rises above the lower lip of the upper screen, when a seal is established, the escape of air ceases and the pressure rises, and further inflow of water is prevented. In the absence of a screen or trap, the escape of air and the inflow of water continues until the tunnel is full, and any attempts to check it by increasing the input of air only aggravate the trouble. A run in a face may be easily caused at any time by a trivial accident or carelessness, but if checked by some such contrivance as the siphon trap, is of no great importance. If, however, it is allowed to develop to the extreme suggested above, it may cause serious delays and



COMPRESSOR PLANT FOR THE MANHATTAN END OF THE PENNSYLVANIA TUNNEL UNDER THE EAST RIVER.
The plant consists of eight Ingersoll-Rand compressors, six cross-compound Corliss and two straight-line, with a combined capacity of 22,000 cubic feet of air per minute. Four of the compressors supply air at a maximum pressure of 50 pounds, the others can deliver at 140 pounds. Steam is supplied by six 500 horse-power Stirling boilers at 150 pounds pressure, and the whole plant is run condensing so far as possible.

greatly increase the cost of tunnelling. It is probably more true in tunnelling than in any other kind of work, that as long as the forces of Nature are kept in check they can be readily dealt with, but once loosed, they are irresistible.

The use of air locks, as suggested in Greathead's shield (page 146) for the North Woolwich tunnel, was to restrict the high-pressure work to the men actually at work in the face. In the Blackwall and the East River Tunnels, it was probably designed to fill a far more important function. A great source of trouble in driving a large tunnel is the fact that whilst the hydraulic head is greater at the invert than at the crown by an amount that depends on the depth of the tunnel, the air pressure which is designed to balance it is the same everywhere. The consequence is that there is either an excess of pressure at the crown or a deficiency at the invert. The former condition results in excessive escape of air, and may cause blows unless the face is kept carefully poled and plastered tight with clay, and the latter allows a flow of material into the tunnel from under the shield and may cause settlement of the shield and other troubles.

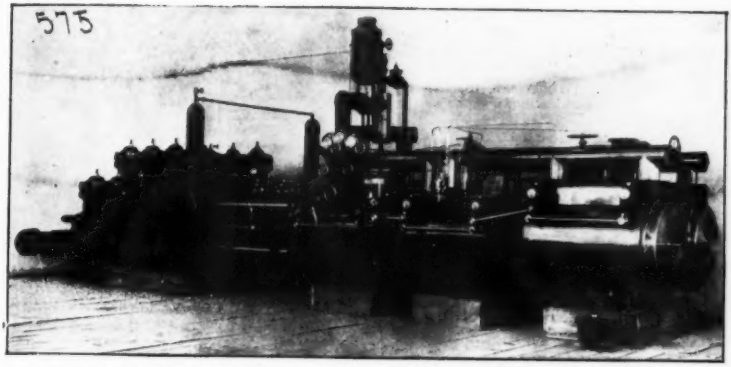
In addition to the difficulties already mentioned, the tunnel builders in New York have had a condition to contend with that did not occur in London, viz., the scarcity of skilled labourers. In London there was a class—it might be almost called a race—of men, consisting largely of Welsh and Cornish miners that could be safely trusted to run the shield with comparatively little supervision and to take care of the details of the excavation and timbering with very little guidance. A pair of plumb lines and a pair of sighting rods hung up in the tunnel near the face to give line and level respectively, graduated rods at the sides of the shields and a line at right angles to the axis of the tunnel, together with some general instructions given to the ganger by the engineer once a day, was all that was required as far as keeping line and grade was concerned, with the addition of a table of distances and corresponding offsets if the tunnel was going around a curve. A little more supervision to prevent recklessness in opening too much of the face, etc., was necessary if the tunnel was passing through gravel. But it has been necessary in New York to train men to their work, and to produce from the rawest material, more or less skilled tunnel builders. This has been a task of considerable difficulty, and until it was accomplished, progress was very slow. When it had been done, the men often formed unions, manifested a desire to undertake the complete management of the work, and were in many ways a source of anxiety.

It is impossible to over-estimate the value of compressed air for

tunnelling through soft ground. It was first used, as before stated, in the construction of the old Hudson tunnel by Haskins in 1879, and as far as tunnelling by its aid is concerned, there has been little change in the method of its application. The locks that are used now are little different from the locks that were used in that tunnel. In his paper on the City & South London Railway, published in 1893, Mr. Greathead said that he had proved that it was practicable to remove the material from the path of the shield by mechanical means, or by a current of water, or by the two combined; and that in such cases, men might work under reduced air pressure, or even under the normal air pressure, at depths below which they could work at all under pressure. There is some evidence to support this in the recent history of the Hudson tunnel, reduced air pressures having been used in silt, but no such method has been applied to sand or gravel, and no tunnel has recently been driven even through silt without compressed air.

Whilst there have been many deaths and cases of paralysis, especially in the early days, and innumerable temporary illnesses caused by compressed air under certain conditions, and whilst there is no generally accepted explanation of the manner in which these effects are produced, there is no doubt, if certain arrangements are made and precautions taken that have been dictated by experience, that men can work with safety in pressures up to about 35 pounds per square inch. On the other hand, it is generally believed, by engineers at any rate, that it is at least undesirable to use greater pressures than these.

These arrangements and precautions have been frequently stated and they cannot be too strongly insisted upon. Obviously, it is necessary that the men should be physically fit and free from heart and lung affections. After this, probably the most necessary condition is that at every point in the tunnel where men are working there shall be efficient ventilation, that the air shall be kept pure and proved so by analysis; this condition is necesssary in all pressures, but a higher standard of purity should be insisted upon in higher pressures. In no case should the proportion of carbon dioxide exceed 1 part in 1,000. Regulation of the time of the "locking out," provision of arrangements for giving the men hot coffee on coming out of the tunnel, for providing them with dry clothing, provision of medical air locks and medical supervision of their use, are precautions the observance of which will tend to eliminate cases of sickness. On the part of the men, abstinence from the use of alcohol, the avoidance of exposure to chills, and the careful observance of the ordinary rules of health are necessary.



TRIPLE-EXPANSION DUPLEX OUTSIDE-PACKED PLUNGER MINE PUMP.

Cylinders 11, 17 and 30 in., plunger 10 in., stroke 36 in. Built by Jeanesville Iron Works Co., Hazleton, Pa.

THE UNWATERING OF MINES IN THE ANTHRACITE REGION.

By R. V. Norris.

THE anthracite region of Pennsylvania, though confined to a relatively very small area in six counties, ships annually over 60,000,000 tons of coal, a far larger mineral production probably than is produced from any similar area in the world. The early mining was largely by water-level drifts which took care of the drainage by gravity, this mining in most cases being continued to the surface, permitting the entrance of surface water through crop falls; these, in the portions of the region where the measures are at a considerable inclination, form an almost continuous line along the outcrops of the beds, and make a very efficient device for conducting practically all the surface water into the mines, and this with the natural mine water makes the drainage problem one of the first importance.

From the figures reported to the State mine inspectors for 1905, it appears that the quantity pumped in the region reached in that year the enormous total of 633,000,000 gallons per day—enough water to supply several large cities, and sufficient to make a river 50 feet wide and 4 feet deep, flowing at the rate of nearly 4 miles per hour; or to fill daily a lake a mile long, one quarter of a mile wide and nearly 20 feet in depth.

When it is considered that all this water must be pumped from depths ranging from a few hundred feet to nearly two thousand, the magnitude of the work is apparent; in fact, fully 8 per cent of all the coal mined is used for steam purposes at the collieries, and of this a large proportion goes to supplying the pumps. In some collieries as much as 40 tons of water are pumped for every ton of coal hoisted, and that from great depths, exceeding in many instances 1,000 feet, and in one colliery reaching 1,800 feet vertical. Where such water conditions exist, instead of a mere 8 to 10 per cent of the output being used for fuel, as high as 40 per cent of all the coal mined is needed for this purpose, so that the operators often wish that they might sell the water and run the coal to waste.

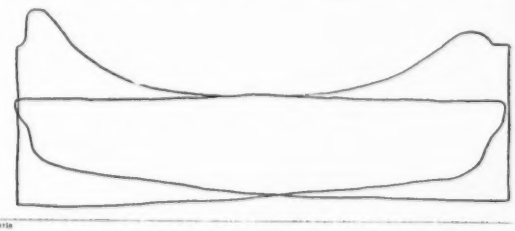
One of the large operating companies figures for the year 1906, on 3,500,000 tons of coal shipped, that they pumped or hoisted 35,500,000 tons of water, an average of over 10 tons of water per ton of coal.

Modern mining methods would leave water-level chain pillars to catch the surface water and prevent its entrance into the deeper workings; but unfortunatly capital was rarely available in the middle of the last century to permit this self-evident precaution, and the water has generally been permitted to pass into the deeper workings, either through direct connections or through cracks and fissures in the strata caused by the subsidence of the worked-out areas. So badly has the surface been caved and fissured in many parts of the region that it has been necessary to build miles of wooden flumes to carry the streams and prevent them from flowing directly into the mines. Such flumes are frequently necessary for mine water, as without this precaution it would often be pumped out at great expense only to find its way back again into the mines through crop falls or fissures. Where possible, too, the outcrops of the seams are protected by ditches arranged to intercept the surface water and conduct it on safe ground to the drainage channels; often a proper arrangement of ditches and their careful maintainance will very materially reduce the quantity of water to be pumped.

In the Wyoming region a large area of the workings lies under the valleys of the Susquehanna and Lackawanna Rivers, and the rock is in many places overlain by water-bearing gravels and quicksands to depths exceeding 250 feet. This condition makes imperative great care in mining to avoid fractures of the rock strata overlying the coal beds; even exploratory drill holes in such territory should be cemented solid to the rock surface, as the water which will flow through even a 2-inch hole under 200 feet head is by no means a negligible quantity.

Even with the most thorough surface precautions there still remains a vast amount of water to be raised.

The earlier pumping plants were of the simplest description, no attempt being made at steam economy, which indeed was unnecessary. All the coal below chestnut size was wasted on the culm banks, and the only cost of steam was the labor of firing and removing the ashes. The pumps were practically all simple, non-condensing, direct-acting single pumps, and frequently of very large size—as 38-inch steam, 72-inch stroke, and 16-inch plunger; these large pumps could be run at a very high plunger speed, 200 feet per minute being not unusual, and even higher speeds up to 400 feet were occasionally attained. Owing to the great weight of the moving parts a card somewhat resembling that of a throttling engine is obtained, as shown below. Such pumps require approximately 50 to 65 pounds of steam per horse-power hour; they are however simple and reliable and raise enormous quantities of water. An improvement in these long-stroke pumps (patented by Jas. Delaney, master mechanic Mineral Railroad & Mining Co.) consists in by-passing, through a check valve, sufficient steam from the pressure side of the piston to cushion the moving parts; this not only improves the steam economy but permits much higher speed.



STEAM CARD FROM OLD STYLE LONG-STROKE PUMP.

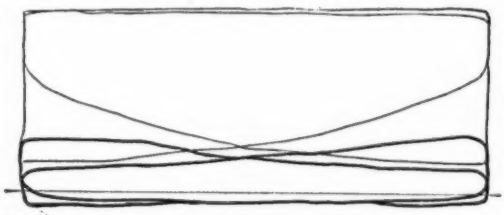
A serious objection to the long-stroke single-acting pump is found in the excessive pressure in starting each stroke, shown by the steam card, this pressure being often twice and occasionally three or four times that due to the head. I have seen a 1,000-pound hydraulic gauge on the column pipe of a 600-foot lift pump broken by excessive pressure.

From the simple pumps the change was rapid to duplex. These, while not helping the steam economy (in fact often reducing it) have the advantage of giving a more regular flow and reducing the impact pressures in the column pipe. An objection to many duplex pumps is found in the fact that with the usual mine attendance they rarely make full stroke, resulting not only in a loss of water capacity but in a very serious decrease in economy. Owing to this the steam consumption of simple duplex pumps of good size is usually in the

vicinity of 55 to 70 pounds of steam per horse-power hour under mine conditions.

Direct-acting multiple-expansion pumps have a great advantage as to steam economy over simple pumps; when it is remembered that in simple direct-acting pumps the steam must follow practically full stroke, it is evident that the economy in compounding such pumps, even with comparatively low-pressure steam, is very much greater than in engines, as the compound cylinders permit the expansive working of the steam besides reducing the cylinder condensation. The cylinder ratios of compound pumps in the anthracite region are usually for non-condensing about three to one, and for condensing four to one, and the steam economy ranges from 35 to 40 pounds per horse-power hour for non-condensing to 25 to 30 pounds for compound condensing pumps.

It would seem that with condensing water available, all mine pumps should be run condensing, but the effect of hot mine water must always be considered. It must be remembered that practically all coal-mine water is acid, and that hot acid is much more active than cold; if the sumps are unduly heated the damage to the pumps is intensified, and a balance must be struck between steam economy with practically waste fuel and maintenance of pumps. The decision whether or not to condense must depend in each case on many factors, and the fact that any particular colliery is pumping non-condensing is by no means proof of poor engineering. Further, the deleterious effect on the roof and timbering of a mine of a hot, moist atmosphere must be considered, and this is often the governing factor in deciding on the type of pump.



CARD FROM COMPOUND CONDENSING PUMP.

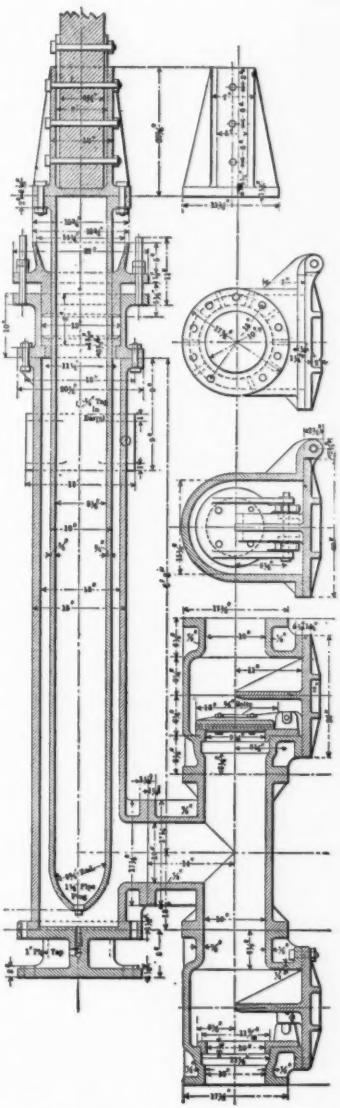
The cost of pumping with an ordinary low-duty plant was determined for the years 1901 and 1902, at the Short Mountain colliery of the Pennsylvania Railroad* accurately and found to be for 1901, 567,113,616 gallons pumped an average lift of 1,141 feet, 4.95 cents per 1,000 gallons 1,000 feet vertical, or 0.6 cent per 1,000,000 foot

* Trans. A. I. M. E., February, 1903, Vol. XXXIV., page 127.

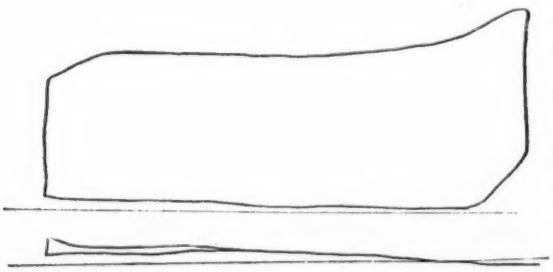
pounds of water; and for 1902, a flood year, 1,116,320,523 gallons pumped an average of 1,093 feet vertical, 3.9 cents per 1,000 gallons 1,000 feet vertical, or 0.47 cent per 1,000,000 foot pounds in water.

A few high-duty pumping plants have been installed in the mines. Notable and probably pre-eminent amongst these is the high-duty plant of the Hazleton shaft of the Lehigh Valley Coal Company. This consists of two compound-condensing flywheel pumping engines 32 and 60 by 48 inches, 13¾-inch plungers, which attained on test an average of 28.93 revolutions per minute, indicated 545.71 horse power, pumped each 5,141,247 gallons in 24 hours, and showed a duty of 103,805,456 foot pounds per 1,000 pounds steam. The delivery averaged 515.78 feet head, and the cost of pumping on an average of five years was 1.998 cents per 1,000 gallons, equal to 3½ cents per 1,000 gallons 1,000 feet vertical, showing that, with a very low cost of coal, steam economy is by no means the largest factor in pumping cost.

Single acting Cornish or "Bull" pumps of huge size were early used, and a very few still remain, as shown here. The steam cylinder is on the surface, connecting by wooden rods with the water plungers; the rods are raised by the steam, and the pumping stroke is made by the weight of the descending rods controlled and cushioned by throttling the exhaust steam

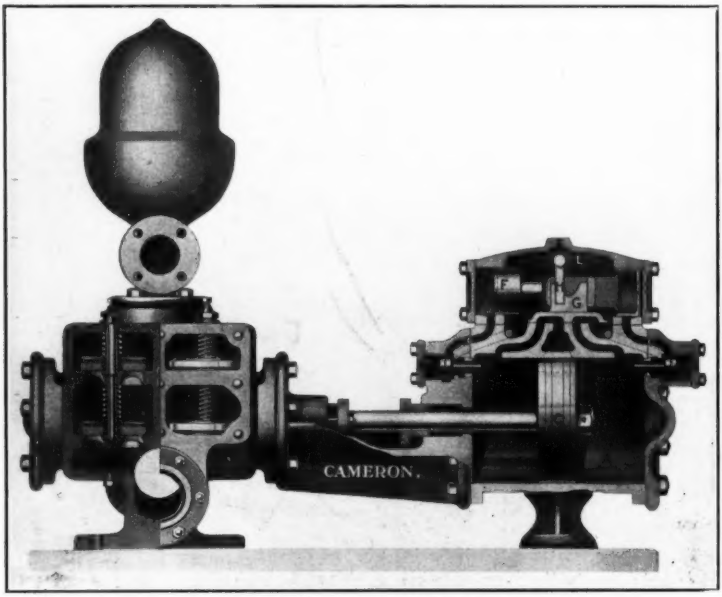


SECTION OF THE END OF A 10-INCH CORNISH PUMP.

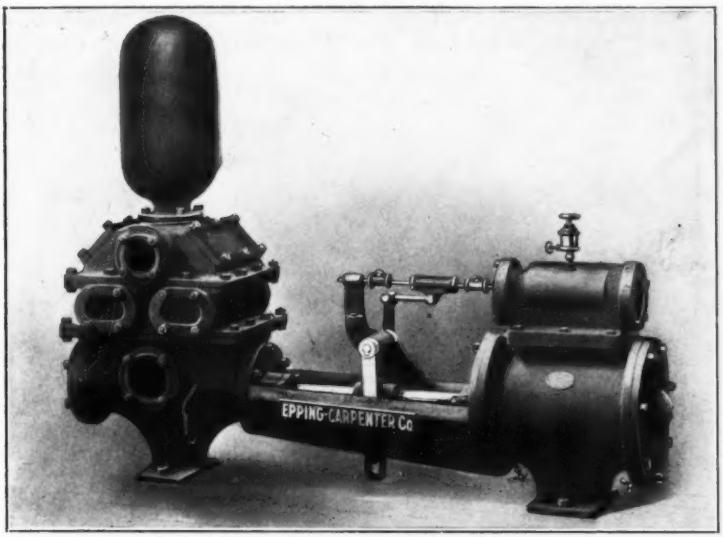


CARDS FROM CORNISH OR "BULL" PUMP.
Above, from the lower end of cylinder, lifting stroke. Below, from return stroke, upper end of cylinder.

which is by-passed into the idle end of the cylinder to keep up its temperature. Such pumps have the advantage of retaining the steam end on the surface, and are not put out of business by flooding; the speed is very low owing to the weight of rods to be handled, about 50 feet useful plunger speed being near the maximum. One such pump tested by me in 1898 was 44 by 116 inch steam, 21½ inch water plungers, made a maximum of 4¾ double strokes per minute on 319 feet vertical lift, and showed a total steam consumption of 49.1 pounds per horse-power hour.



A TYPICAL SELF-CONTAINED COMPACT MINE PUMP.
It will work at almost any angle.

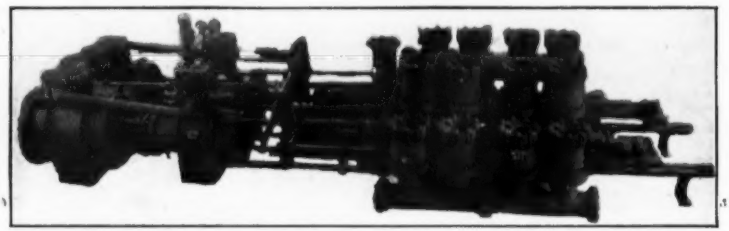


ANOTHER TYPICAL SINGLE-PISTON MINE PUMP.
Positive and certain in operation, under all conditions, on admission of steam. Epping-Carpenter Co., Pittsburg.

In many cases, as in sinking, it is important that the pumps be so designed as to require a minimum of attendance, and be as little as possible liable to damage from falling rock. In such cases short self-contained pumps are very largely used; these have the advantage of working in a very contracted space and not requiring to be placed perfectly level. In unwatering flooded slope workings where the pumps must be lowered down the pitch as the water recedes, it is of prime importance to select such types of pumps as will work in an inclined position; for this work pumps with a relatively low number of spring-closed valves are satisfactory, while those with a large number of guided metal valves closing by gravity are to be avoided; the valves are apt to cock sidewise and stick, causing constant losses of time in taking off the covers and freeing the valves.

In the work of unwatering it is of great advantage to keep counters on all pumps and have the revolutions of each pump reported daily by an independent observer. There are too many cases of attempted unwatering where the daily report "we are holding the water" seems to be considered satisfactory. There must for this work be ample pumping capacity and every pump must be made to count by being driven to its limit. As the pumps must be continuously

moved as the water recedes, it is manifestly desirable to use pumps of moderate size and simple construction, and not to attempt steam economy.

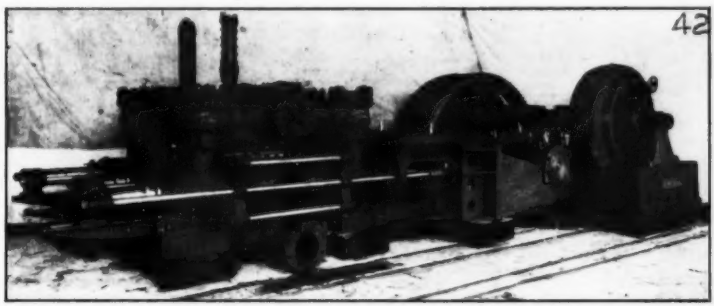


COMPOUND CONDENSING MINE PUMP, PHOENIX PARK COLLIERY, P. & R. C. & I. CO. Weight 135,000 lb.; capacity 2,500,000 gal. daily; 861 ft. lift. Steam cylinders 42 and 24 in., plunger 12 in., stroke 48 in. Note separate valve chambers and suction air column. Goyne Steam Pump Co., Ashland, Pa.

The design of mine pumps involves considerations not found under ordinary conditions. The valve chambers should be so placed that the valves and seats are easily accessible for repairs and renewals; valve chambers should not be cast as integral parts of the working barrels; all packing should be readily accessible, and the metal of the water end should be very heavy to allow for considerable eating of the castings by acid water before renewals are necessary. Some duplex pumps are so arranged that either side may be run independently; such an arrangement may be of immense importance in case of accident, permitting of the repair of one side of a pump at a time without total stoppage of pumping.

All mine pumps should be provided with very ample air chambers both on the suction and on the column, the former so arranged as to take the suction water-hammer in a direct line from the suction pipes beyond the valves; suction air chambers placed between the suction and the valves are of very little service. Where height is limited, a Y in the column pipe close to the pump with a couple of pieces of column blanked off at the top on one branch makes a very satisfactory and efficient column air chamber. Usually the entrained air will be ample to keep the air chambers full, but it is well to arrange for means of accomplishing this mechanically when necessary, and to insist on the air chambers being kept constantly in working order. A "run around" arrangement of suction pipe on duplex pumps or a central suction pipe is also an advantage in reducing the suction impact and assisting in the rapid closing of the valves, thereby reducing slip. Where the mine water is very acid, the water ends of pumps

require protection; this may be secured by using anti-acid bronze linings, or even bronze water ends, or by lead lining. Both of these methods are efficient but costly; a cheaper and equally satisfactory protection is found in wood-lining all parts exposed to water; to do this satisfactorily the water end must be designed for the purpose and completely lined, usually with dry pine wood driven into place and swelled with fresh water just before being put in use. Column pipes are also frequently wood-lined; this is best accomplished by making the lining of staves *sawed* to shape with a fine saw and the joints *not* planed; when swelled the rough sawn joints interlock and form a tighter joint than do planed strips. The wood lining should project slightly beyond the ends of the iron pipes so that the gaskets rest directly on the wood; of course if the acid water gets behind the wood lining its usefulness is gone, so that after swelling with fresh water the linings should never be allowed to dry out. Such linings carefully put in have protected for years the cast column pipes in collieries where the water is so acid as literally to eat all the iron work from a shovel left in the ditch for a single night.



TRIPLEX DOUBLE-ACTING ELECTRICALLY DRIVEN PLUNGER PUMP, AVONDALE COLLIERY OF D. L. & W. R. R.

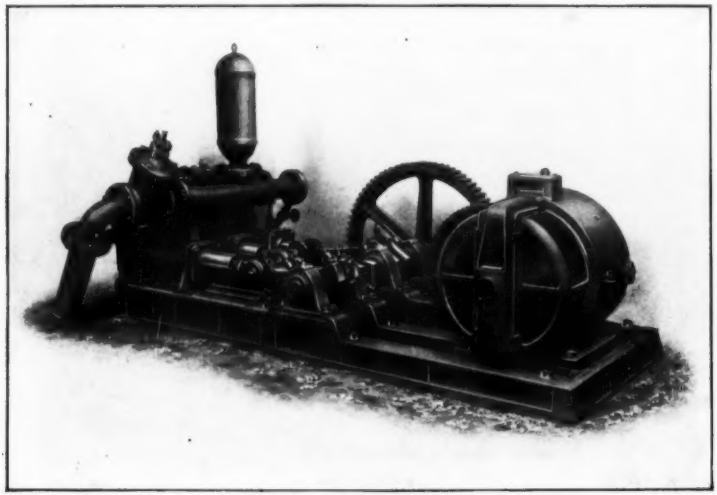
Capacity 800 gal. per min., 800 ft. lift. Jeanesville Iron Works.

Sumps for mine water are usually in the coal, generally in the form of a dip working; they should be at least of sufficient extent to hold one day maximum water, and are frequently much larger.

Important pumps should always be put in good pump houses, and too much weight cannot be put on the necessity of having the pump houses fireproof. Very many, if not most, mine fires start in timbered pump houses, where more or less grease is sure to be found; the best arrangement is either to wall and arch the pump houses with masonry and put in concrete floors, or in pitching seams to drive them in the

rock and use exclusively steel and masonry supports for the roof. All waste should be kept in covered metal cans or metal closets, all oils carefully protected, and cleanliness enforced—not an easy contract. Open lights should never be allowed in pump houses or pumpways; where electric lights are not available closed lanterns should be absolutely insisted on. Further, all loafing or waiting in pump houses must be absolutely prohibited.

Pump columns should not be taken up the hoisting compartments in shafts, nor up working slopes, to avoid the double danger of injury to the pump column from accidents in hoisting and injury to the hoisting plant from breakages in the column.

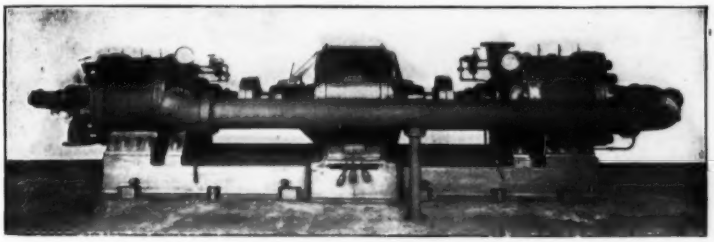


TRIPLEX SINGLE-ACTING PUMP FOR 200 GALLONS PER MINUTE AGAINST 400 FFET HEAD.

Driven by four-pole 35 horse-power motor. Automatically started and stopped by relay switch connected to float. J. H. Holmes & Co., Newcastle-on-Tyne.

Occasionally it is practicable to place the pumping plant in an underlying or overlying seam from that mined, conducting the suction pipes through a rock tunnel so dammed that the water may raise to a considerable extent in the mine without flooding the pumps.

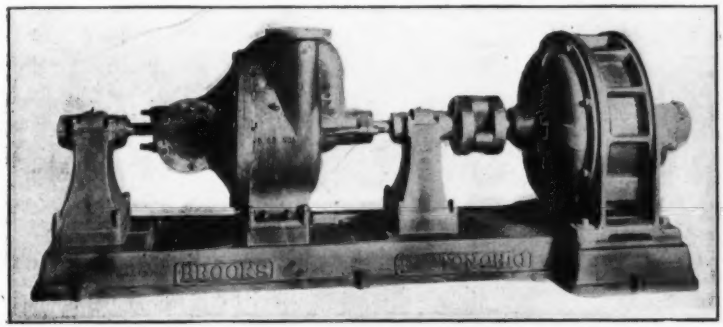
In some instances it is possible to drive drainage tunnels from adjacent valleys to the coal basins, placing a large portion of these above water-level and greatly reducing the head required for pumping from the lower levels. Notable amongst such tunnels are the "Centralia" tunnel, about 9,000 feet long, driven in 1889, draining a number of collieries near Ashland; the "Jeddo" tunnel, about 3½ miles



WORTHINGTON EIGHT-STAGE PUMP, 900 GALLONS PER MINUTE, 1,350 FEET HEAD.

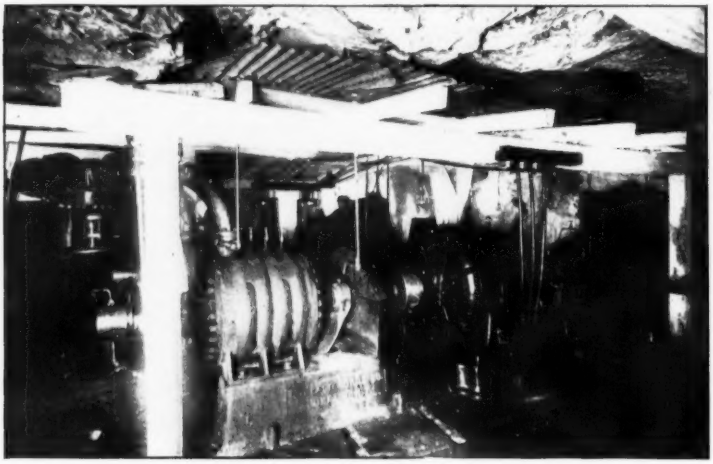
long, driven by G. B. Markle & Co., to drain their collieries near Hazleton; the "Quakake" tunnel completed in 1906 by Coxe Bros. & Co., and the Lehigh Valley Coal Co., to drain collieries in the Beaver Meadow basin. All of these have been successful and have fully justified the expense of driving in the reduction of drainage costs. They have the further advantage of absolutely safeguarding the workings above the drainage level from flooding during cessations of work, such as the last two anthracite strikes, and making unnecessary the operation of the steam plants and pumps under armed guards at such times.

A very comprehensive drainage-tunnel proposition is now under construction by the Lehigh Coal & Navigation Company, to drain their collieries in the Panther Creek Basin. This company is driving a drainage tunnel from the Lehigh River near Mauch Chunk, starting at an elevation of 537 feet above sea level, and rising with a grade of 13 feet per mile to extend in tunnel and water-level gangways all the way to Tamaqua, over 12 miles away. The scheme when completed will involve about 24,000 feet of rock tunnel and 54,000 feet of water-



TWO-STAGE CENTRIFUGAL PUMP FOR WORKING AGAINST HEADS UP TO 200 FEET.
Dayton Hydraulic Machinery Co.

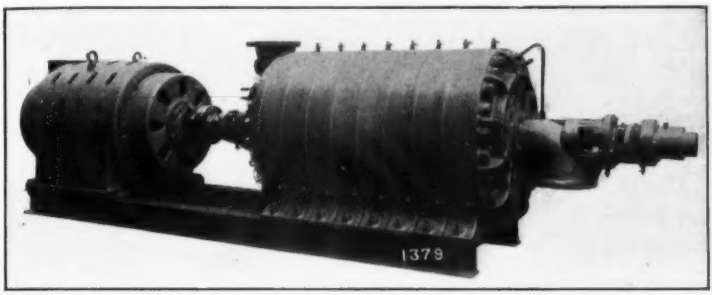
level gangway in the coal; the cost is estimated by Mr. Baird Snyder, Jr., general superintendent, to be about $700,000 and the annual saving to be in the vicinity of $150,000. Most of this company's collieries will be placed above water level for a number of years, and the pumping lift of the deeper ones reduced by about 400 feet vertical.



EIGHT-STAGE CENTRIFUGAL TURBINE PUMP INSTALLED IN A MINE.

For 300 gals. per minute, 1,400 ft. lift; 250 horse-power motor. Buffalo Steam Pump Co.

While it is perfectly practicable to pump in single lifts to heights of 1,000 feet or more with moderate sized pumps, the difficulties with valves and column pipes in larger pumps are such that it is the general practice in the anthracite region to confine single lifts for pumps of 10-inch plunger and over to approximately 600 to 700 feet; a notable instance of this is in the new pumping plant of the Lykens Valley Coal Company, where an old plant (described fully in February, 1903, Trans. A. I. M. E. Vol. XXXIV, page 127) has now been replaced by a modern compound condensing plant. The total depth of about 1,650 feet vertical has been divided into three lifts, the lower lift 665 feet vertical taken care of by two Jeanesville compound condensing direct-acting duplex pumps, 38 inch and 25 inch steam, 10 inch plunger, 36 inch stroke, and the two upper lifts of approximately 500 feet each, by eight similar pumps 16 inch and 36 inch steam, 12 inch plunger, 48 inch stroke, wood-lined (four installed on each lift). The pump houses are all in rock in the "Whites," a small vein overlying the Lykens Big Vein, and are fully

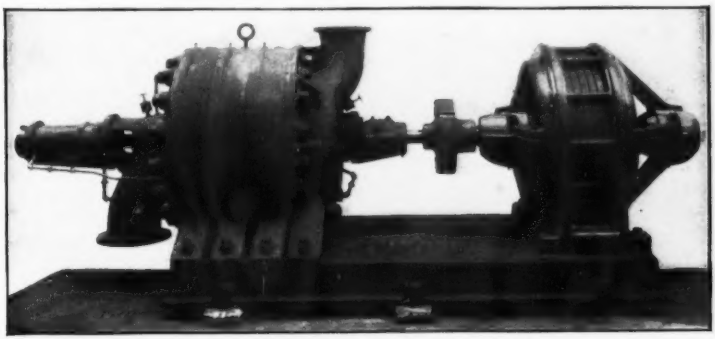


HIGH-LIFT TURBINE PUMP AND MOTOR.

For 700 gals. per minute at 750 ft. head. Three-phase motor of 375 horse power, 2,500 volts, 1,140 revolutions. Ernest Scott & Mountain, Gateshead-on-Tyne.

fireproof; the columns are also in the "Whites" vein and fully protected from danger from the other workings. Only a small portion of the water reaches the lowest level, and the pumps at this are protected from the main workings by dams so that it is possible to flood the lower mine workings to a depth of over 200 feet before putting these pumps out of business; this condition actually occurred during the last strike, when the Lykens workings were flooded to a very considerable depth above the level of the pumps, only such water as these could conveniently handle being admitted to them through valves in the dams. These lower pumps are notable for having worked some years ago for over a month under an average of 30 feet of water; the pumps were left running when the colliery was flooded and actually pumped themselves out.

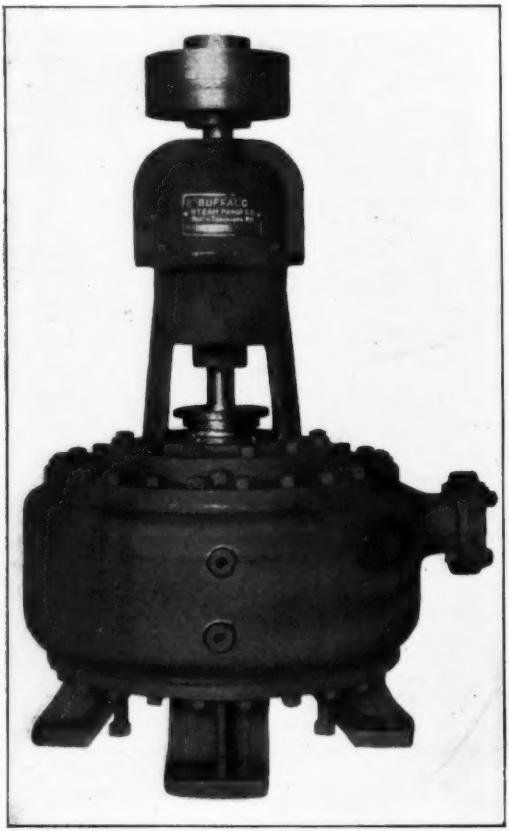
While the practice of running pumps under water cannot be commended on economic principles, the simply constructed pumps



WORTHINGTON 4-STAGE TURBINE PUMP, 2,000 GALLONS PER MINUTE.

used in the region can generally be depended upon to run for considerable times under this condition, and that too without much injury to the mechanism. I am familiar with one small pump which has been under water most of the time for years on one of the Lehigh region collieries, and which could be started and stopped at will by merely opening the steam valve on a higher level.

In some instances it is necessary to run pumps by compressed air, usually in cases where the heat from steam pipes and from exhaust steam has a serious effect on the roof. The pumps used for this purpose are usually ordinary steam-type pumps, but a few have been built with special attention to clearance with a view to increasing the efficiency of the air. As the condition requiring air usually precludes the possibility of re-heating, the efficiency is low, probably in actual practice with the pumps as used rarely reaching 25 per cent; a large plant tested gave 21½ per cent efficiency between the indicated powers of the compressors and pumps.

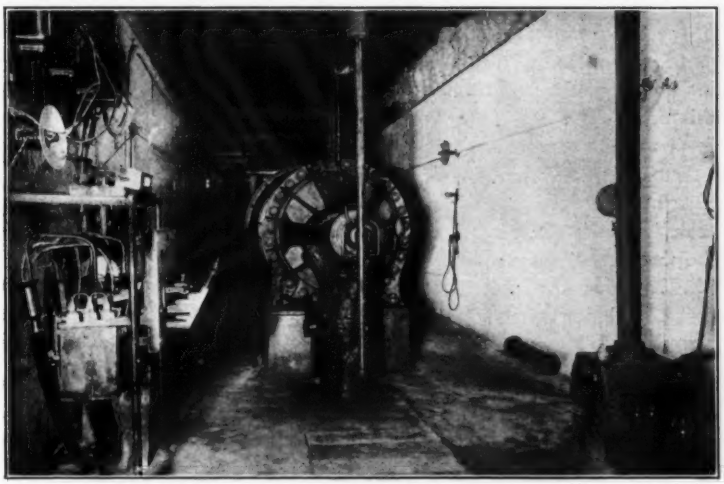


TWO-STAGE VERTICAL-SHAFT CENTRIFUGAL PUMP.
For 150 ft. head; 1,440 revolutions. Buffalo Steam Pump Co.

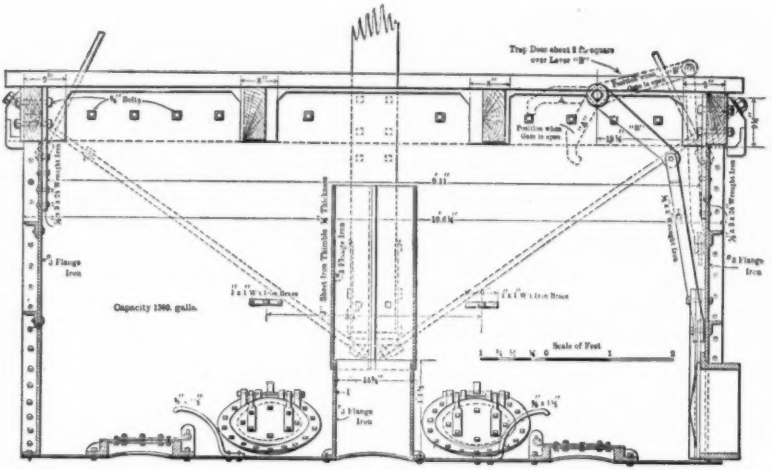
Electrically driven reciprocating

FIVE-STAGE CENTRIFUGAL PUMP WITH CASING REMOVED.
Capacity 1,000 gals. per minute, 520 ft. lift. Jeanesville Iron Works, Hazleton, Pa.

pumps (pp. 167, 168) of relatively small size are largely used in collieries equipped with electrical plants. These are particularly convenient and efficient for dip workings below the general drainage level; and large centrifugal electrically driven pumps of the multiple-stage type (pp. 170-173) are coming into use; notable amongst these is the 10-inch six-stage electrically driven centrifugal pump, with a rated capacity of 5,000 gallons per minute, now successfully operating at the Hampton Shaft of the Delaware, Lackawanna & Western Railroad Company, in Scranton. Pumps of this type have not been in use long enough to determine fully their qualifications for the work, but



SIX-STAGE ELECTRICALLY DRIVEN WORTHINGTON CENTRIFUGAL PUMP, HAMPTON WATER SHAFT OF D., L. & W. R. R.
Operating against a head of 485 ft.; capacity 5,000 gals. a minute. General Electric 3-phase 2,300-volt motor of 900 horse power. Photograph by courtesy of H. M. Warren.



CAGE TANK, SUSQUEHANNA COAL COMPANY.

thus far are said to be giving excellent service; no accurate data as to their economical performance have yet become available.

Another largely used method of drainage consists in hoisting the water in vertical shafts. This was regularly done at the No. 1 shaft of the Susquehanna Coal Company (Pennsylvania Railroad), as early as 1880 by means of a tank (shown above) suspended under the regular hoisting cage; no other means of handling the water existing at this time. The use of a separate shaft with tanks especially designed for water hoisting was probably initiated at the Luke Fidler Colliery (Pennsylvania Railroad), Shamokin, in 1896, by Messrs. Irving A. Stearns, manager, and Morris Williams, superintendent of the Mineral Railroad & Mining Co. This practice is now very common for the deeper collieries; the early plants were described Trans. A. I. M. E., February 1903, Vol. XXXIV, page 106. In this paper the cost of hoisting was shown to be for three prominent water-hoisting plants, as follows:—

	PLANT.		
	Luke Fidler.	Wm. Penn.	Lytle Coll'y.
Depth shaft	960 ft.	953 ft.	1,500 ft.
Record: gallons 24 hours	.....	2,291,140	3,772,600
Capacity of tanks, gals.	1,400	1,440	2,600
Cost per 1,000 gallons	$0.0306	$0.0234	$0.0219
Cost per 1,000 gallons 1,000 feet vertical	$0.032	$0.029	$0.028

The Fidler costs were from an average of three years' work, the

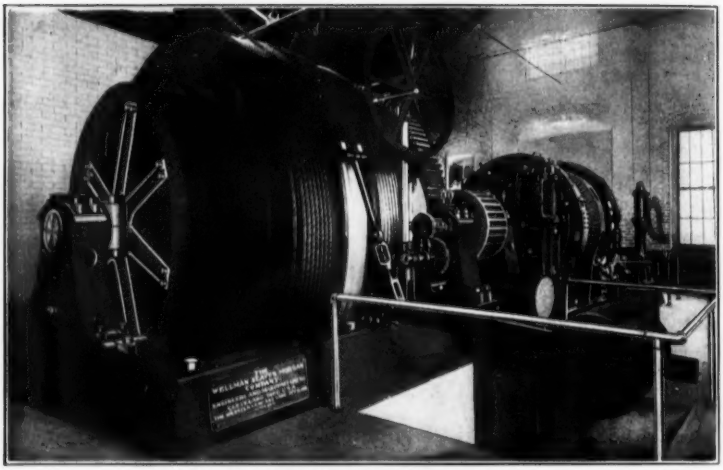
Lytle and William Penn collieries from unwatering after the flooding due to the 1902 strike.

The hoisting is done by very large first-motion engines, hoisting at very high speeds (page 176). The 1,500-foot hoist at the Lytle shaft has frequently been made at an average of 50 seconds per trip, including filling and dumping. The duty of the 36 by 60 inch first-motion water-hoisting engines at the Lytle shaft was found to be approximately 33,250,000 foot pounds per 1,000 pounds of dry steam, and the cost of the installation, complete for 2,300,000 gallons daily capacity, including shaft sinking, machinery, and steam plant, was $80,777.96.

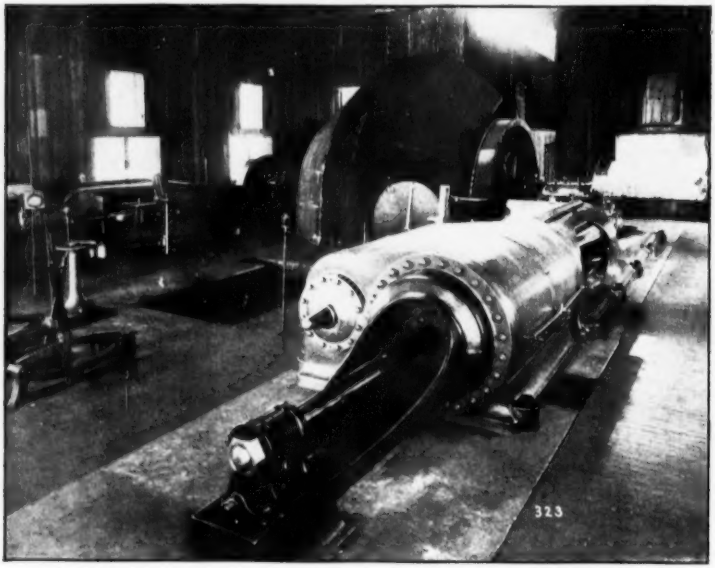
DISCHARGE OF A WATER-HOIST TANK.
L. C. & N. Company's No. 10 Colliery.
Tank capacity 3,000 gals. Engines, first motion, 42 by 60.

The tanks are now generally cylindrical, and are made either to dump (as shown on pp. 177-178) or to discharge from the bottom,

WATER HOIST OF THE HAMPTON SHAFT, D., L. & W. R. R.
Built by the Wellman-Seaver-Morgan Co.



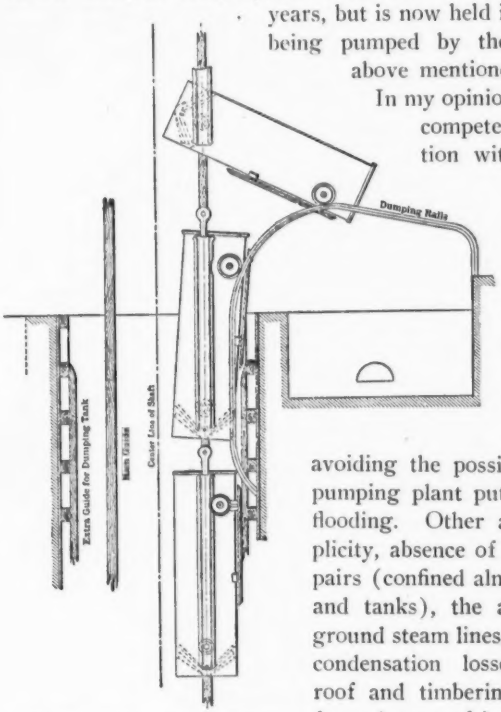
AUTOMATIC ELECTRICALLY OPERATED WATER HOIST.
Built for the Hampton Shaft of the D., L. & W. R. R. by the Wellman-Seaver-Morgan Co.



FIRST MOTION WATER-HOIST ENGINES, LYTLE COAL CO., MINERSVILLE, PA.
Cylinders 36 by 60; cast coned drums 12 to 16 ft. diameter; two steam-actuated band brakes. Shaft 1,500 ft. deep. Tanks 2,600 gals. capacity each; time of hoist 43 seconds.
Vulcan Iron Works, Wilkes-Barre.

as illustrated above in which case spout castings are necessary, and these of the double discharge type give the minimum of trouble.

A very interesting electrically operated water-hoisting plant has been installed at the Hampton Shaft of the Delaware, Lackawanna & Western Railroad Company; this plant, built by the Wellman-Seaver-Morgan Company, has been successfully operated for several years, but is now held in reserve, the water being pumped by the centrifugal pump above mentioned.

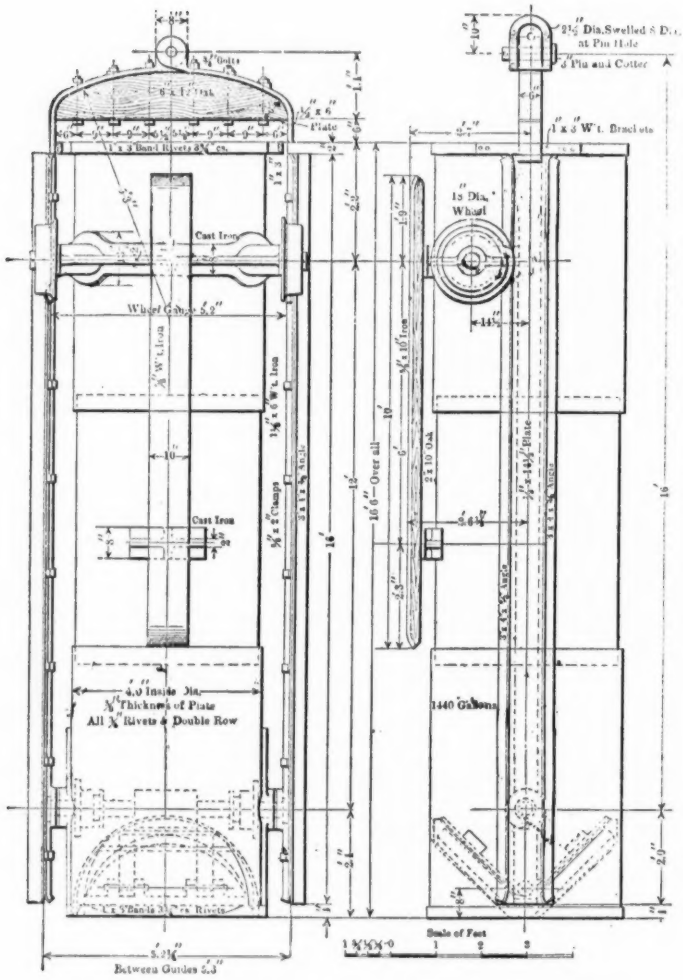


SHOWING GUIDES AND METHOD OF DUMPING.

In my opinion hoisting plants can compete in cost of operation with modern pumping plants only at depths well above those practicable for pumping in single lifts; hoisting has, however, the inestimable advantage of having all the machinery on the surface and avoiding the possibility of having the pumping plant put out of business by flooding. Other advantages are simplicity, absence of slip, low cost of repairs (confined almost entirely to ropes and tanks), the avoidance of underground steam lines, with their attendant condensation losses and damage to roof and timbering, and the freedom from danger of interruption from falls or squeezes in the mines.

It has been notable that where a water-hoisting has replaced a pumping plant the quantity of water previously figured on plunger displacement has invariably diminished to about 60 per cent of that previously reported. The difference is accounted for partly in slip, and partly because proper allowance is rarely made for delays and low speeds in mine pumps, which until recently were rarely provided with counters.

When conditions warrant the expenditure, the combination at the



WATER HOIST DUMPING TANK OF THE WILLIAM PENN COLLIERY.

Delaware, Lackawanna & Western Railroad Co., Hampton Shaft, of pumps for regular work with a water hoist in reserve, would seem for low and moderate lifts to give a promise of the combination of maximum economy and absolute safety.

EDITORIAL COMMENT

SOME months ago, commenting in these columns upon the huge increase in the production of gold (which was then beginning to impress many observers as the most significant phenomenon of the times) we pointed out that it was attended by another, of possibly even higher potentiality—the gigantic demands on our finances imposed by the expansion of industry. We remarked that, while the world's store of primary money was being enlarged at a rate never before known, the production of other forms of wealth and the attendant demands for machinery, transportation, and tributary construction of every kind were advancing at a pace never before dreamed of.

Mr. Del Mar's noteworthy study in this issue demonstrates the conclusion that this second phenomenon has overtopped the first in magnitude and has really become the controlling influence in present economic conditions. And since his paper was in type, the impressive utterances of Sir Hugh Bell, president of the Iron and Steel Institute, have urged the same view, and it has been confirmed and repeated again and again by financiers at the National Convention of the American Bankers' Association, which has just closed.

The world's resources cannot be developed as rapidly as they are being produced, nor as largely as they are being demanded, simply for lack of money. An extraordinary situation to confront a whole great nation—a situation which may change the rate of our activities somewhat during the process of readjustment, but one in which "depression" is out of the question. Everything organic in our national life is sound; the functional disorder of a constricted currency system is within certain reach of cure.

THE confusion which befogs many students of phenomena of this class comes from economic nearsightedness. They exhaust themselves in survey and study of the meanderings of a small stream, when the problem involves the regimen of a whole watershed.

The larger point of view is ably taken in Dr. Douglas's analysis of the copper situation, which leads this number. He deals not with the flurries and dips of local and temporary oscillations, contenting himself with pointing out that the close margin between demand and supply makes such wide occasional fluctuations inevitable; but he draws the great curves of production and consumption so firmly that their trend and meaning are plain to all. And the result is wholly reassuring to those who depend upon the copper industry, either as buyers or as sellers. In brief, his article is not for the speculator; it is for the miner, the machinery builder, and the manufacturer. And by these it will be valued as its authority deserves.

* * *

THE greater the strain which passing conditions put upon the economic system, however, the larger the part which confidence has to play in maintaining equilibrium during the period of readjustment. At times, therefore, when the symptoms even of an ultimately wholesome change give rise to a certain general nervousness, it would be well for all who are active in public affairs to see that they move carefully. It is not necessary that offenders should go unpunished for fear their arrest might startle society, but it is well that the arrest should be made without wanton shouting and firing in the air. We shall never have a sound and safe civilization until corporate honesty and

corporate obedience to law have become a national habit; and it is to be feared that they will not become a habit until corporate dishonesty and disobedience have been severely punished. But the greatest effect and the greatest good will follow when the punishment descends with the greatest dignity and the least tumult.

And further, however upsetting to bystanders the clamorous castigation of offenders may be, the artificial hysterics of those who oppose all policing of our erring corporations are more harmful. We need sanity and straightforward justice on both sides.

* * *

IT is quite possible that the anti-railroad legislation now so much indulged in finds popular favor for reasons more human and less moral than would first appear. No doubt abuse of franchise privilege and opportunity is a very serious civic offense, but its effect and gravity are borne in upon but few individuals. Secret rebates, however reprehensible, do not touch the mass of the people to the quick as they seem to have been touched. Something more than discontent with fares as they are popularizes the two-cents-a-mile legislation. It is quite possible, as hinted above, that another animus is at work, and that it is nothing nobler than revenge for the "petty tyrannies" of the transportation companies. Everyone who travels has tramped rebelliously the weary and devious distances imposed upon him by our badly designed terminals; he has fumed at the delays of slow-scheduled ferries—slow-scheduled, apparently, in order that they might be overcrowded; he has struggled, luggage-laden, through narrow and congested gateways where his ticket must be shown for the needless inconvenience of a preliminary punching, or, if not a traveler, he has been turned back from this same gate and denied the privilege of seeing even an invalid or an aged relative safely down the long platform to the cars. He has been chivvied hither and yon by employees in brass hats, more or less surly, but always inexorable in "enforcing their rules," at no matter what expense of annoyance or actual loss to the passenger. And he is sore. Plush and mahogany have not sufficed to soothe him. His sense of decency and justice has been trampled, and now that he sees what seems an opportunity, he is willing to trample in his turn. Vanderbilt's "the public be damned," like other curses, comes home to roost.

* * *

THE Quebec bridge disaster, reviewed elsewhere in this issue, is appalling in its deliberateness. The Tay bridge went down in as sudden and utter ruin, but it had stood to its appointed work for years, and collapsed before a Titanic onslaught of Nature which had not been conceived possible by the mind of its builders. The Quebec bridge, before it had even attained the dimensions for which it was designed or endured its first service test, crumpled up on a summer afternoon.

The commission now investigating the wreck may well be trusted to answer finally and fully all the questionings of the engineering world. So far, the key to the physical aspects of the collapse seems to lie close to the now sadly well-known bottom chord A9L. It is noteworthy that Mr. A. W. Buel is disposed to attach much more importance than some other authorities do to the field injury and repair to this particular member. So far as we have seen, the fundamental re-study of the design has not yet been completed. And the thought will recur that this Quebec cantilever, while designed to be the longest in the world, had not yet exceeded the dimensions of the Forth bridge—and the Forth bridge is standing like a part of the natural Earth itself.

REVIEW OF THE ENGINEERING PRESS.
"THE WORLD IS ITS FIELD"

THE QUEBEC BRIDGE DISASTER.

AN ANALYSIS OF THE AVAILABLE EVIDENCE AS TO THE CAUSES OF FAILURE OF THIS IMMENSE STRUCTURE.

Engineering News.

THE failure of the Quebec bridge may fairly be classed as the greatest disaster which has ever overtaken an engineering structure. The bridge was to be the largest of its kind in the world, but it was simple in design and all the problems involved were accurately determinate. All possible care was bestowed on its design by men who are leaders in the civil-engineering profession, and even the details of construction were carefully considered and specified before the work commenced. Both materials and workmanship were of the highest order of excellence and were subjected to the most rigid examination and inspection. It is evident, then, that none of the ordinary causes of bridge failure was responsible for this disaster, and that the real cause has to do with the fundamental principles of engineering construction, the theories as to the strength and behavior under stress of built-up members, which form the bases of bridge design. This is the ground taken by *Engineering News* in an editorial analysis of the available evidence as to the cause of failure of the Quebec bridge, of which the following is an abstract. The general details of the bridge and of the failure are too widely known to require recapitulation.

"It may seem to the reader that it should be an easy matter to promptly settle, beyond possibility of doubt, what caused the wreck by an examination made on the spot. The first sight of that gigantic heap of torn and twisted steel promptly negatives such an idea. Only the most careful expert analysis can determine the hidden cause of the wreck. Elsewhere in this issue we have endeavored to record the chief superficially available facts regarding the disaster; such as are needed to enable an engineer to form in some degree his own opinion. Here we shall try to set down the deductions which the facts seem to permit. We make no pretense that the analysis is complete. Time has been insufficient and the data have been incomplete.

"At the time this is written, at Quebec, on the fourth day after the wreck, *the initial cause of the wreck appears to be the failure of some compression member in the anchor arm of the cantilever.*

"It is important to trace the analysis leading to this conclusion, an analysis independent of what we recount, in our descriptive article, about the curiously buckled ninth bottom chord of the west truss.

"(1) Neither the main pier nor the anchor pier show the slightest sign of settlement or failure. They are monumental examples of high-class masonry, and, except for a few coping stones displaced or broken by the falling superstructure, both piers are, to all appearance, absolutely uninjured. It is possible that the impact of the superincumbent mass may have loosened the bond of the cement in places, but this cannot yet be determined. But it is certain that the piers still stand in place,

with the truss bars on the main pier and the anchorage in the anchor pier still there. The piers did not cause the fall.

"(2) *The initial failure was not in a tension member.* This is so important that we deem it well to show the proof in detail as follows:

"*a.* Had a tension member failed first it would have snapped with a loud, sharp report or a series of reports as successive eyebars in a panel parted, which would have impressed every eyewitness. All accounts agree that the very first yielding was silent. The first warning was when the men felt the floor sinking beneath them.

"*b.* Had a tension member failed, especially one of the top-chord members, the structure would have dropped instantly, like a falling body. The failure did not occur in this way. The hazy accounts given by eye-witnesses agree in the one fact that the collapse was rather gradual, at least in its first stages. A time of 10 to 15 seconds is indicated. The time-keeper, who was near the anchor end and had to run up-hill to safety, must have occupied at least this much before he turned around. This man, by the way, does not report jumping a gap at the anchorage, although a gap must have opened there at once if the anchor arm was the seat of the failure. But there are now hanging from the approaching span three long strings of track rail, about 75 ft. long, which pulled away from the rest of the track on the bridge; these doubtless carried their ties with them for a time and bridged a gap, if a gap did form. The absence of a gap, therefore, argues neither for nor against compression failure or anchor-arm failure. But the slowness of the fall points to a compression member as the one to give way. The gradual fall could not possibly occur in the case of sudden snapping of an eyebar, or, rather, a panel of eyebars.

"*c. The eyebars of the upper chords of the anchor arm are intact, unbroken and still joined in a continuous chain,* from the bottom of the anchor pier clear across the pile of wreckage, over the top of the main pier until they disappear in the waters of the St. Lawrence. In all that pile of torn and twisted steel there is only one single broken eyebar thus far discovered, and that is but one bar out of 26 composing that particular top-chord member. It is true the top anchor chain fell on top of the pile of wreckage, and, naturally, suffered much less than the members at the bottom; yet there are places where eyebars received terrible punishment, were bent, twisted and distorted, and in spite of this, during a whole day's examination by two of the editors of this journal, not one eyebar, with the single exception noted, was found with even a crack across its edge. The importance of this fact to the art of bridge engineering we shall enlarge upon at another time. Its bearing on the question whether a tension or compression member caused the wreck is the point we would emphasize now.

"(3) The failure did not occur in a compression member of the river cantilever arm.

"If a strut had collapsed somewhere near the end of the river cantilever, the rest of the structure shoreward would have remained standing, or, at least, would have very slowly collapsed progressively and probably not far toward shore. All accounts agree with the appearance of the anchor-arm wreckage in showing that the failure did not occur in this way. There is, indeed, a bare possibility that a failing member on the river side of the main pier and near the pier might have buckled the towering main post over this pier and so caused the wreck of the structure; but everything indicates that this is not a correct record of the failure. As the wreck lies, the members, with the exception of some members of the bottom chord, have all been dragged over toward the river, due, it is believed, to the fall of the river arm as a whole, dragging the top chord and its attached members with it, when the failure in the anchor arm deprived the river arm of support. The main tower posts are bent and broken, it is true; and very badly broken. But this would have been caused both by the collapse of the web members attached to them on the shore side and by the riverward pull of the eyebar chain over their tops. The survivors agree, moreover, in the opinion that failure began in the anchor arm.

"(4) The failure was in a main truss member and not in the cross bracing.

"All the wind and sway bracing was in place and fully connected, and there was no wind of any account when the bridge fell. Further, the trusses fell quite generally in the plane of their original position. The evidence of witnesses, moreover, speaks of no sidewise swinging, but only of the downward motion.

"(5) The probabilities are against the failure beginning in a main post above the floor level. The time-keeper, who was facing the probable point of failure, had his first warning by feeling the floor yielding beneath him. A buckling upper post within a hundred feet or so of him would almost certainly have been seen.

"(6) No indication as to the probable point of failure is to be seen in the fact that the wreck of the anchor arm on the foreshore lies slightly to the east of its original position. The center of gravity may be 8 to 10 ft., more or less, east of its location when the span was in position on the piers. But when the great height of fall is considered, it is impossible to conclude anything but that the structure, or its anchor arm at least, went down in perfect verticality.

"Thus the probability is established, we think, that a compression member in the anchor arm, and that member not a post, but a section of the bottom chord, was the seat of initial failure.

"It may be thought that the next step, locating the actual responsible member, would be easy; that one need only go to the site, examine the wreck, and point to the weak link. The facts set forth in our descriptive article as to the buckling tendency noticed in the ninth left bottom-chord section may seem to the reader to put the matter practically on the basis of a certainty. This would be far from warrantable. Not what went before, but what happened at the time, is called for. This must rest wholly on the evidence of the wreckage. The task of constructing herefrom an explanation is not an easy one.

"But at present the explanation of greatest probability is the failure of this ninth left-hand bottom chord. This explanation rests on one most weighty fact: Of all the bottom-chord sections of the anchor arm (all of which have been fairly well traced) there is only one that exhibits characteristic buckling distortion, and that is this ninth chord. All the others are bent and crushed, broken at the splices, cracked across, burst open, and most variously battered, but none has a well-defined buckle. The ninth of the left truss, however, is not merely buckled in indisputable manner, but it is doubly bent in a closely folded S-shape, and both its ends still lie practically in their original direction. Did this chord crush as a *result* of the fall? That event happened to all the posts, as our photographic views show strikingly, but not to the chords. The posts had the crushing endwise impact of the fall to withstand, but the chords only fell laterally. A chord member swung forward against the pier masonry might well be buckled. On the left side a tendency in this direction is indeed observable in the eighth chord. But the ninth chord lies far from the pier, in place, as it were, and can hardly be conceived to have returned after striking the stonework; especially is this obvious as chord 10 lies not far out of place as compared with its original position relative to the ninth, being on the pier side of chord 9.

"We believe that the most thorough study of all that relates to the present and past state of chord A 9 L must be among the first things to engage the attention of those charged with the investigation of the disaster.

"We have already alluded above to the lack of absolute knowledge as to the strength of steel columns of enormous size, such as were of necessity used here. These compression members were designed for a unit stress under full dead, live and wind loads of 24,000 lbs. per sq. in., about two-thirds of the elastic limit of the metal. They were carrying at the time of failure not more than two-thirds of this amount. Were these compression members able to safely carry this stress? Were the plates and angles of which they were built up so thoroughly braced and connected together as to make the whole member act as a unit? Their design was made and approved by the ablest engineers in the profession. No one has dreamed of doubting their strength; but now, with the testimony of that gigantic collapse, every engineer must long to know, by absolute trial, what such columns can safely bear.

"It is at exactly this point that the Quebec Bridge failure becomes of importance to the whole engineering profession. Until the cause is absolutely determined—if indeed it can ever be—or until the profession has actual results of tests of huge columns at its command, a cloud of doubt rests upon us as to the margin of safety in every great bridge structure; at any rate when the unit stresses are forced up to the point deemed safe by the designers of this bridge."

THE ICE PROBLEM IN ENGINEERING WORK.

A DISCUSSION OF THE IMPORTANCE OF THE ICE PROBLEM IN HYDRAULIC POWER DEVELOPMENT IN NORTHERN LATITUDES.

Howard T. Barnes—British Association for the Advancement of Science.

THE development of water powers is greatly complicated in northern latitudes by the ice problem, an element not considered in Mr. von Schon's recent series of articles in THE ENGINEERING MAGAZINE but which is occasionally of fully as great importance and worthy of as careful study and investigation as the variations in flow due to floods and drought. An interesting paper on the ice problem, referring especially to Canadian rivers, was presented by Dr. Howard T. Barnes before the recent meeting of the British Association for the Advancement of Science. Dr. Barnes is widely known as an authority on the formation of ice, his researches carried out in the St. Lawrence being of a most elaborate and careful character and extending over a long period of years.

"During the severe Canadian winter there is excellent opportunity for the physicist to study, on a grand scale, the operation of the natural laws governing the formation of ice in the many forms with which it is met in the large and often turbulent rivers. To the engineer the problem is more serious, for the development of the vast water-powers of the country must include means of combating the ice troubles which arise each winter. What presents itself during the summer months for consideration is small compared to what must be met during the winter months, when ice is forming rapidly, and ice-bridges, dams, and shoves, may change the whole character of the levels and channels in a single night. Rivers are thus known to have been turned entirely out of their course into new channels during a winter of unusual severity, and in some instances the reversal of a rapid is of yearly occurrence. No one set of conditions may be said to hold from year to year, on account of the variation in the severity of the winters. Therefore, before an engineering scheme is carried out, a careful study is usually made of neighbouring conditions, previous summer and winter levels, and deductions made from a consideration of native traditions over an extended region round about.

"In general, three kinds of ice are distinguished, and present characteristics brought about by their method of production. Surface or sheet ice forms over the surface of quiet lakes or rivers, and is desirable or not, depending on the particular conditions. Spicular-ice, or, as it is called in Canada, frazil-ice, is formed by surface agitation in the more turbulent rivers and in water-falls, and accumulates in great quantities in the quieter waters. It is this form of ice which gives the most trouble in hydraulic work. It varies in size from thin plates to fine needle crystals, depending on the degree of agitation of the water. Anchor ice, or ground ice, is the most interesting, from the fact that it grows along the bed of a river not protected by surface ice, and often causes considerable inconvenience when it rises in great masses, carrying up with it boulders and stones of considerable size. Anchor ice is formed, in the first instance, by radiation of heat during a cold clear night, but increases to great depths by entangling and freezing large quantities of the frazil ice carried down by the shifting currents.

"A study of the temperature conditions in the water during the production of these forms of ice shows that this is accompanied by a small temperature depression in the water amounting to a few thousandths of a degree Centigrade. During the severe weather the water is thus thrown into a

slightly supercooled state, during which time the ice crystals are growing rapidly by continued freezing, and giving rise to the agglomerating stage when they stick together into lumps and spongy masses, and adhere to the racks or to the machinery of the wheel-gates or turbines. So firmly does the ice freeze that it will interfere in a short time with the operation of the machinery, and cause a temporary cessation of operations. The rack-bars frequently become clogged with ice, and cut off entirely the supply of water. Fortunately, it is only a small temperature depression which brings about these conditions, and methods of artificial heat, applied about the affected spots, are found effectively to relieve the situation. The sun is the most powerful agent in preventing ice troubles, since the absorption of the heat rays prevents the state of supercooling. At night, however, it has been found most important to have available a system of steam injection, or electric heating, which can be readily applied about the machinery, in order to prevent it from becoming supercooled. It is not found necessary to warm the entire volume of water passing through, which would be very costly and difficult; but by applying the heat in the racks or wheel-cases, or blowing steam about the affected parts, the ice is prevented from gaining a foothold. The ice is as effective as so much water in producing a head; hence the necessity of passing it through, and not allowing it to freeze to the metal surfaces of the machinery.

"In places where the steam-injection system is installed, no trouble is experienced, even in the most severe weather; thus completely demonstrating the feasibility of coping with a situation which, for many years, has been regarded as involving inevitable interruption to the continuous operation of the plant.

"The hanging dams of frazil-ice accumulate in great quantity under the surface ice, and tend to produce a uniform flow of water throughout the spaces under the ice. Thus, in the quieter spots, larger masses accumulate. In this way the under surface of the masses is found to follow more or less completely the contour of the bed of the river. In some parts of the St. Lawrence, thicknesses 80 ft. deep have been measured by a sounding-rod let down through the spongy accumulations through an opening in the surface ice.

"Anchor ice grows in large quantities during the severe weather, not only by radiation, but by the general adhesive properties of the frazil-ice during the time in which the water is in a super-cooled condition. Open portions of the St. Lawrence are observed to rise, during cold weather, several feet, owing to the accumulation of ice on the bottom. This accumulation is not without benefit to power-users while it lasts, for it is probably the most effective agent in clearing the water from frazil-ice that is known. Shooting up in long needle crystals through the water, taking arborescent forms, it attaches and filters a great deal of fine floating ice swept down by currents. It is a matter of comment amongst power-users that there is less fear from ice-troubles during prolonged cold weather than when the weather is intermittently warm and cold, a condition which keeps the bottom fairly clear of anchor ice.

"Once the ice gains a foothold on the metal surface of the machinery, it does not take long for it to accumulate, and cause a serious falling-off, or a complete stoppage, of the wheels. It has now been found possible to prevent this by passing a steam-pipe into the wheel-case, and blowing steam into the water whenever the ice shows a sign of sticking. It is not often that this is necessary, but chiefly at night or when the sun is not shining. A turbine, losing capacity, is found to pick up its load within five minutes of turning on the steam, and occasional injections of steam during a severely cold night are found to have beneficial results.

"Many of the Canadian rivers, such as the St. Lawrence, are subject to winter floods, occasioned by the accumulation of frazil and disintegrated anchor ice. Wherever a stretch of open water intervenes, an immense quantity of frazil ice is produced, and is carried down with the currents far under the surface ice covering the quieter portions. Large hanging dams of ice are thus produced, which frequently so reduce the available water-way as to cause the waters to rise until sufficient head is produced to deliver an effective blow at the obstruction, and clear a passage-way.

"There is evidence to show, by the character of old river-channels, that some rivers have been completely turned from their courses to find new ones. That this might be accomplished during a winter of great severity, by an ice-bridge or jam, seems perfectly evident, when the tremendous upheavals are witnessed which take place at various points on a river like the St. Lawrence.

"All these conditions must be considered in the location of a power company, and great care must be exercised. When works are supplied by water from a river completely frozen over, little trouble is ever experienced. The most effective prevention to the formation of both frazil and anchor ice is the protection afforded by a surface sheet. When a power-house is located at the foot of rapids, or at the head of a rapid with open water above, means are taken to construct a head-race of sufficient magnitude to serve as a settling basin for the ice drawn in. Much of the ice is deflected at the head of such a channel by the construction of booms or crib-work. Even in this case a large staff of men may have to be employed to cut channels through the ice of the head-race to allow of sufficient water for the turbines.

"In cases where a channel to a power-house is fed from rapids, the growth of surface ice over the channel is often a disadvantage, and artificial means are employed to keep the channel open. The frazil-ice which passes under the booms is passed along as quickly as possible, and handled by artificial heat at the wheel-house.

"So many and varied are the problems to be met, not only from the varying conditions of locality, but also from the variation in the severity of the winters in any one locality, that it is only by a general study of the laws governing the formation of ice that means may be found to cope with the situation. It may safely be said, however, that the ice problem in Canada is no bar to the future development of her vast water-powers."

THE PROPULSION OF SHIPS.

A DISCUSSION OF THE UNSOLVED PROBLEMS OF SHIP PROPULSION AND THE PRESENT POSITION OF THE MARINE STEAM TURBINE AND INTERNAL-COMBUSTION ENGINE.

Francis Elgar—Institution of Civil Engineers.

FOR some years the James Forrest lectures before the Institution of Civil Engineers have discussed the unsolved problems of engineering, drawing attention to the direction in which the aid of the physicist is more immediately required by the engineer. This year's lecturer, Mr. Francis Elgar, following the established custom, presented an elaborate paper on "Unsolved Problems in the Design and Propulsion of Ships," with particular consideration of "the direction future progress may be expected to follow in the production of even finer and faster liners than those which now traverse the ocean for trading and commercial purposes." The greater part of Mr. Elgar's paper relates to the architectural side of ship design. The following extracts are taken from the section dealing with the mechanical problems of propulsion.

"The greatest problem of all with regard to the propulsion of ships is the form which propelling machinery is likely to take in the immediate future. Already an important change is in progress from the ordinary reciprocating marine engine to the steam-turbine; and the question is not only how far that change will extend, but also whether the whole of the cumbrous apparatus required for producing steam may not before very long be swept out of mercantile steamers, and the power be obtained from some form of internal-combustion engine. It would be rash to attempt to prophesy what will happen, but a short reference to what appears to be the present position with regard to these fundamental questions might be expected.

"The progress of the steam-turbine is remarkable. It has often been described by Mr. C. A. Parsons and others, and is pretty well known. The reasons why its progress has not been greater, and why it is not already more generally employed in ships of all classes, are not so well known, and

it might be useful to consider them. The Parsons steam-turbine has practically superseded the reciprocating engine in the battleships, cruisers, and smaller very fast craft of our Navy; and it has had equal success in the very important class of Channel steamers and other boats of similar type. Turbine-steamers now employed on cross-Channel services are running at speeds that could not be reached with the best reciprocating engines. They are strictly limited in many cases to a very shallow draught of water; they carry very little dead-weight of coal and cargo; the weight of their machinery and boilers constitutes a large proportion of their gross weight, and the percentage of the latter that is saved by the use of fast-running turbines is sufficient to give a substantial advantage in speed. The coal consumption compares favourably with that of the best reciprocating engines of equal power that could be fitted in that type of ship; and still better, of course, with the paddle-engines or screw-propeller engines of old type which were in the boats they superseded.

"When these facts are stated, as they often have been, surprise is expressed by many that such apparent advantages are not secured more extensively for other classes of vessels. Very few ocean steamers have been fitted with turbine machinery or are being so fitted; and although this may not cause surprise in the case of cargo-boats and other vessels of low or even moderate speeds, it appears strange that liners of high speeds are still being fitted with reciprocating engines, and that the bold lead given by the Cunard Company with their two fastest new boats and the Carmania should not be generally followed.

"The chief reason for hesitation to put turbine machinery into ocean liners is the doubt which exists as to coal consumption. The amounts at stake are so large in these costly vessels when experiments with novel propelling machinery are tried that everybody prefers to see some one else make them. The Cunard Company are making the crucial experiment upon the largest scale that is now possible, and every one interested in progress must wish those responsible for it all the success they hope for and deserve. But the result is to some extent uncertain, and the immediate future of the turbine in fast liners depends greatly upon the issue.

"In warships the consumption of coal has been brought down to 1.7 lb. per equivalent indicated horse-power of reciprocating engines per hour, and to about the same figure in mercantile boats of cross-Channel type. That is as good as can be obtained with reciprocating engines in the same classes of vessels, as weight has to be kept down as much as possible in these by shortening the stroke, and using high mean pressures of steam in the cylinders, in order to get all the power that is practicable out of a moderate size and weight of machinery. It pays better, in these cases, to stop somewhat short of the maximum efficiency attainable than to carry the additional weight that the increase would involve. In ocean liners the conditions are different, and economy of consumption is the chief point aimed at. Their consumption with quadruple-expansion engines and a boiler pressure of 210 lb. to 220 lb. has been brought down to 1.3 lb. of coal per indicated horse-power per hour. The substitution of turbines for reciprocating engines in ocean vessels depends chiefly upon whether the consumption with turbines can be brought down to this figure, and there is no satisfactory evidence that this is now practicable. It is probable that the marine turbine will ultimately be so improved as to beat the best reciprocating engines in economy of consumption in ocean liners, but no proof is forthcoming that it can yet do it.

"In ocean liners the turbine has to compete with the reciprocating engine at its best, and the development of high efficiency with the turbine is counteracted by loss of propeller efficiency as speed of turning is increased. The problem is to secure a combination of turbine and propeller such as will give an efficient speed of turbine without reducing unduly the diameter of propeller, and experience with regard to this is much needed. The smaller propellers of turbine engines doubtless gain in efficiency on service by being immersed more deeply, and being thus less affected by the rising and falling of the sea at the stern. This is especially the case with some of the cross-Channel boats, in which the propellers have

to be so large relatively to the shallow draught of vessel with reciprocating engines, even when these are run at the greatest possible number of revolutions per minute, that they are sensibly affected by the least disturbance of water-level. The difference in propeller efficiency soon becomes very marked as the weather gets bad. In the Newhaven and Dieppe service, for instance, it is found that whereas the turbine boat Brighton only gains an average of three minutes upon the time of the reciprocating-engine boat Arundel in fine weather, she gains fifteen minutes in anything like bad weather. The difference in favor of the turbine on account of extra immersion of propeller is not likely to be so great as that in ocean liners, because in them the immersion of propeller is not relatively so unfavourable with reciprocating engines, but it would doubtless be of appreciable value. There appears to be some other cause, however, which operates unfavourably in bad weather at sea, especially when running against a strong head wind, to turbine vessels with comparatively small propellers. In such circumstances they fall off in speed more than reciprocating-engine boats with their large propellers would do; and, altogether, notwithstanding the greater depth of immersion, the efficiency of the propellers appears to diminish more rapidly as they are reduced in diameter, when driving the vessel against a head wind and sea. . . . . .

"The question of some form of internal-combustion marine engine which would be suitable for large ocean vessels is still about where it was when Mr. Milton's paper was read and discussed here last January, and I do not feel that I could now add anything with advantage to that paper and discussion. I will merely enumerate the conditions, most of which were mentioned by Mr. Milton, that must be satisfied by a successful marine engine of any type whatever.

1. The engine must be reversible.

2. It must be capable of being stopped quickly, and of being started quickly, either ahead or astern.

3. It must be capable of being promptly speeded to any desired number of revolutions between dead slow and full speed, and of being kept steadily at the required speed for any length of time. 'Dead slow' ought not to be faster than one-quarter of full speed, and should be less in very fast vessels.

4. It must be capable of running continuously for long distances, with but short intervals between the runs, without risk of stoppage or breakdown.

5. It must be capable of working well, not only in smooth water, but also in heavy weather, in a seaway in which the varying immersion of the propeller causes rapidly-changing conditions of resistance.

6. All working parts must be readily accessible for overhauling, and all wearing surfaces must be capable of being promptly and easily adjusted.

7. The engine must be economical in fuel, especially at its ordinary working speed.

8. It must be compact, light in weight, and well balanced, so as not to cause vibration.

9. It must not involve any risk of accumulation of gas in the ship such as could form an explosive mixture.

10. It is a *sine quâ non* that it must be capable of using a fuel whose supply at moderate price is practically unlimited, and that could be readily obtained in whatever part of the world a ship might happen to be.

"We have since heard of gas and oil machinery for 16,000-horse-power battleships, but this only exists at present in imagination. It is impossible for anyone to judge by what has been achieved up to the present in this direction what weight or space, or what consumption of fuel, would be required for the internal-combustion engines of great power that might, perhaps, ultimately be made to fulfil the onerous requirements of marine work. Engineers and metallurgists may, by working together, succeed some day in overcoming the difficulties of producing large cylinders which will stand the high impulses and great and rapid variations of temperature that occur with internal combustion; but till that is accomplished no great step ahead can be taken. There are no two opinions, however, as to the advantages that might be gained by doing away with the present boilers and their appurtenances, and abolishing with them that very arduous and

disagreeable class of labour known as 'marine stoking.'

"The subject of oil-fuel for marine boilers is an interesting one, but I have no time to say more about it than that great practical advance has been made in its use during the last decade, and a consumption as low as 0.9 lb. per indicated horse-power per hour has been regularly realised in mercantile vessels which employ the system of spraying the liquid for combustion by means of hot air. American steamships have used oil-fuel largely during the last three years, under a combined system of high and low-pressure air respectively for desiccating or pulverising the oil before combustion, and for assisting the combustion afterwards. This system has proved highly successful and economical. Vessels of 14,000 tons displacement belonging to the Shell Transport Company have made voyages regularly and successfully from Singapore to this country by the long route of the Cape of Good Hope, and still larger vessels have made equally successful voyages from New York to San Francisco *viâ* Cape Horn, the use of oil fuel in both cases giving a high economy."

SPEED TRIALS OF THE LUSITANIA.

THE RESULTS OBTAINED ON THE OFFICIAL TRIALS OF THE NEW TURBINE STEAMER OF THE CUNARD LINE.

Engineering.

THE Lusitania represents the greatest step that has ever been taken either in size or power in a merchant ship, apart altogether from the adoption on a great scale of the turbine system of steam propulsion. The remarkably successful outcome of the official trials is, therefore, a matter of great interest and importance, no less to the marine-engineering profession than to the Cunard Company whose courage in making such a tremendous experiment merited the fullest measure of success. The following record of the official speed trials is taken from recent numbers of *Engineering*.

"The Cunard liner Lusitania has, in her official trials, carried out under the direction of the technical staff of the Cunard Company and of the Admiralty representatives, met the most sanguine anticipations of all concerned. At a draught of 30 ft., she has steamed over 26 knots on the measured mile; on a 48 hours' sea run on long measured distances she has maintained a mean speed of 25.4 knots. The contract anticipated a speed of 24½ knots on the round voyage on the Atlantic, and this will be easily achieved.

"Justification for this view is found in the fact that the long-distance trial represented exactly the conditions of the Atlantic voyage. The unprecedented length of the trial precluded 'jockeying.' The course of about 300 miles was traversed four times in alternate directions, so as to eliminate the influence of tide and weather. And thus any speed maintained on such a trial may be continued indefinitely, so long as coal and other supplies are available. It is unnecessary to say that the machinery worked satisfactorily. The general result stated carries conviction from this point of view. Before entering upon this, the most crucial test, at midnight on Monday, July 28, the Lusitania had made several preliminary trials on the Clyde measured mile, not only to tune up the turbine machinery, but to standardise the relation between revolutions, power, and speed, so that a series of trials could be made to determine the coal consumption at various speeds. These economy tests began on Saturday, when, with a large company of guests of the Cunard Company and of Messrs. John Brown and Co., Limited, the owners and builders respectively, the Lusitania left the Clyde for a cruise around Ireland. The vessel was loaded to a draught of 32 ft. 9 in., equal to a displacement of 37,000 tons, and on the cruise the water and coal consumption were taken while the vessel ran for six hours at speeds of 15, 18 and 21 knots respectively. The results were thoroughly satisfactory, but the data obtained were in connection with service requirements rather than scientific purposes; the results on the Atlantic will be more valuable.

"The guests were transferred to the tender at the Mersey Bar on Monday, and thereafter the more exacting tests were entered upon, water and coal consumption data at 23 and 25 knots being taken. On the run to the Firth of Clyde, the starting-point of the full sea-speed trials, the course measured out on the chart was between the Corsewall Light on the Wigtownshire Coast to the Longship Lighthouse at Lands End, and this had to be traversed four times, alternately north and south. The compass bearings gave the distance, which aggregated about 1,200 miles; the trial began at midnight on Monday, and ended about 1 o'clock on Thursday morning. The weather was favourable, with cloudless days and starlight nights; but on both nights north-west winds freshened to forces of six and eight, and although this occurred when the vessel was steaming north, and somewhat increased resistance and slightly reduced speed, it brought consolation in the fact that it prevented fog. The feature of the trial was the uniformity of the speed on both runs south and on the two runs north, the latter being against the wind and tide. The course, as a glance at the chart would show, was divided into three approximately equal parts by the Fodling and Tuskar lights. Compass-bearings taken at these intermediate points proved the uniform rate of steaming. The time taken on the runs south, on Tuesday and on Wednesday, differed by only two minutes; further proof is unnecessary of the great regularity of steam-supply or of turbine efficiency. The speed on four runs was: South, from Corsewall, 26.4 knots; north, from Longship, 24.3 knots; south, from Corsewall, 26.3 knots, north, from Longship, 24.6 knots; mean speed, 25.4 knots. We omit second place decimals, but, in any case, the percentage of error in observation is, with such distance, negligible.

"This is a great performance: it exceeds by two nautical miles per hour any similarly long run made. The truest significance lies in the uninterrupted mechanical precision with which every unit of the machinery worked. The air pressure in the ashpits of the boilers did not at any time reach the maximum of ¾ inch prescribed in the specification by the Cunard Company. The boiler pressure averaged 186 pounds per square inch, while the pressure at the receiver of the high-pressure turbines varied little from 150 pounds; at the low-pressure receiver it was 3½ pounds. The mean vacuum was 28.2 inches, with an average barometric reading of 29.8 inches. The mean revolution of the four shafts were 188 per minute, and the power, according to the torsionmeter, was 64,600 horse-power. To those not versed in the details of steam-turbine performances the fact is illuminative. The circumferential or tip velocity of the rotors of the low-pressure turbines was 150 feet per second, equal to over 9,000 feet per minute. The general procedure in the machinery department accorded with Atlantic practice, and Tuesday's and Wednesday's performance might to all intents and purposes have been two days running, each equal to over 600 miles, on a voyage to New York. This will certainly be the condition a month or six weeks hence. On returning to the Clyde on Thursday, the vessel proceeded on shorter distance tests between Corsewall and Chicken Rock, the southern extremity of the Isle of Man, and between the Holy Isle and Ailsa Craig, in the Firth, while following this were progressive runs on the measured mile at Skelmorlie, also on the Clyde; these ranged up to 26 knots, as already indicated in our introductory sentence.

"The steering qualities of the vessel have also been tested. When steaming at 15 knots the rudder was put from amidships to hard over, both to port and starboard, in 15 seconds, and the full circle was completed in 8 minutes. Immediately before commencing to turn, the engines were running at the rate of revolution which gave 15 knots. A careful record of revolutions was made on a time basis during the evolution, and it was found at the completion of the circle that the rate of revolution was then 70 per cent. of the rate at 15 knots. The final speed was thus assumed as 10.5 knots, the average speed 13 knots, and the diameter of the circle about 1,100 yards. This for a ship of this great length is a most satisfactory performance; the ship, at 22 knots, made the complete circle in 7½ minutes, with 15 degrees of helm. In ordinary steering the

ship answered her helm very rapidly, according to the testimony of the pilot, and her swing was easily checked. Although the weather was very fine, alike on the 36 hours' run around Ireland and on the 48 hours' trial on the deep-sea course, there was sufficient swell on the Atlantic in the first-named trip, and between the Tuskar and the Longship Light on the subsequent runs, to cause pitching and rolling motions to be perceptible and to afford opportunity for repeated records. In respect to these points a large number of observations gave the period of a single roll from side to side as almost exactly 10 seconds; a single pitch occupied 4 seconds. This latter result calls for no remark and the slow rolling indicates that, while the vessel has a satisfactory measure of stability, the long period of roll assures us that there will be the minimum of discomfort to passengers through this cause. . . . . .

"On Thursday the vessel, at slightly less draught, proceeded on a double run between Corsewall Light and the Chicken Rock, at the extreme south of the Isle of Man. The distance between these points is 59 odd miles, and the vessel on the southern run averaged 26.7 knots, and on the northern run 26.2 knots, giving a mean speed of 26.45 knots. This, it must be admitted, is a particularly fine performance, surpassing even the best record made on the measured-mile trials. Following upon this trial further speed tests were made. There were six runs, alternately north and south, between the Holy Isle, on the east coast of Arran, and Ailsa Craig Light; and here again most satisfactory results were achieved. It is not, however, necessary to enter into details regarding these, because they simply bear out the results previously obtained. Several runs were made to determine the speed for given revolutions or power at various draughts: but unless most complete data were published, general results might be misleading. The main point is that the contract speed has been far exceeded, and that when the vessel enters on the Atlantic service on September 7, she is certain to meet every expectation formed by the owners and builders, and, one might also say, by the general public."

ELECTRIC TRACTION IN ITALY.

A DISCUSSION OF THE ECONOMIC IMPORTANCE OF ELECTRIC TRACTION IN ITALY AND THE RESULTS ALREADY ATTAINED.

Philippe Tajani—Revue Economique Internationale.

ELECTRIC traction for trunk line operation has been developed to a greater extent in Italy than in any other country. In America, for instance, where coal is still abundant, electric traction on railways has been applied, so far, only to short suburban lines where the conditions of traffic require frequent and fast train service. In Italy, however, the lack of coal and the abundance of water powers have made the substitution of electric for steam power on railways a matter of national economic importance and electric traction has been developed with a view to the eventual operation of all the railroads of the country by electric power. A recent article by M. Philippe Tajani in the *Revue Economique Internationale* gives an interesting account of the economic considerations which have determined the lines of development of electric traction and the encouraging results which have been attained.

As soon as the possibilities of electric traction were recognized in Italy, the government took steps to conserve all the more important water powers of the country for national uses. Italy is absolutely dependent on other countries for her coal supplies and besides the large drain upon the resources of the country caused by the large purchases of coal for railway purposes, the condition was most unsatisfactory from a military standpoint and also seriously interfered with the internal traffic movements of the country. It was recognized, therefore, that the introduction of electric traction on all the railroads was a matter of the greatest importance economically, in that it would develop the national resources and remove to a large extent the necessity for importing large amounts

of coal. The problems of electrification were approached, therefore, with a view to the ultimate operation of all lines by electric power and it was kept in mind that while a reduction of operating expenses was to be desired, it was not the primary consideration. The national aspect of the change from steam to electricity was never lost sight of in the preliminary investigations and in such developments as have taken place, and this fact is to a large extent responsible for the leading position Italy now holds in electric trunk-line operation.

The preliminary investigations of the problem occupied a long period of time and the most important result was the adoption of the three-phase, high-tension alternating current for the transmission of power. They further showed that no radical changes could be made in the actual methods of exploitation of the railroads with the change from steam to electric power. The Italian engineers had begun their work on the assumption that the change would mean the substitution of light, fast trains for the heavier and slower ones used with steam traction, but they were forced to abandon this idea, both on account of the requirements of traffic and a consideration of operating costs. It was seen also that separate locomotives would give better results than would be obtained by placing the motors in the cars.

The only line on which a complete substitution has been made is on the so-called Valentina line, 105 kilometres long, which has been widely described in the technical press. M. Tajani gives a description of the locomotives, etc., which we omit as being already well known. His discussion of the economic effects of the change, however, brings out some interesting facts, which apparently show that electric traction cannot be expected to make such large reductions in fixed charges and operating expenses as some of its advocates claim. M. Tajani points out, however, that a slight saving has been made and that the results obtained on this experimental line are a satisfactory evidence that electric traction can be installed, in the course of time, on all important Italian railways without adding to the costs of operation.

Concluding, M. Tajani summarizes the principles on which further extensions of the system will be based. "Our programme does not anticipate any astonishing results: we are satisfied if we can operate our railroads by means of our own natural resources at no greater expense than with steam traction. We will not be able to do this on all roads, for in some cases the traffic is too small to make the change from steam to electric power, and in others water powers are not conveniently located for the generation of electricity; but we have already attained one important result in that we can affirm that we have established electric traction on trunk lines under the same conditions as steam power, without lessening the size of trains, without restrictions in operating methods, and at no greater expense."

AUTOGENOUS WELDING WITH ACETYLENE.

THE APPLICATIONS OF THE OXY-ACETYLENE BLOWPIPE AND THE ADVANTAGES OF THE OXY-ACETYLENE OVER THE OXY-HYDROGEN FLAME.

Ernest Schneider—Scientific American Supplement.

As mentioned by Mr. Kershaw on another page of this issue of THE ENGINEERING MAGAZINE, the calcium-carbide industry has been given a new impetus by the introduction of the oxy-acetylene blowpipe for the autogenous welding of metals. This process has been largely developed on the Continent and is used to a considerable extent in England, but as yet it has been adopted in the United States by only two or three firms. Its advance is likely to be rapid, however, for it offers numerous advantages over the oxy-hydrogen system of autogenous welding. These advantages, and the applications of the oxy-acetylene flame, are interestingly enumerated in an abstract, in a recent number of the *Scientific American Supplement*, of a paper presented before the technical department of the Workmen's Union, Chemnitz, Germany, from which the following extracts are taken.

"The Fouché process with acetylene and oxygen is the latest in the line of autogenous welding. About ten or eleven years ago, as acetylene became known, the industrial world was certain that it would find important applications in the useful arts when employed in combination with oxygen; but the technical difficulties were great. In employing the Daniell burners there was formed at the mouth of the jet, by reason of the high percentage of carbon in the acetylene (92.3 parts by weight), deposits of graphite. When, however, the gas was mixed in the interior of the burner, the unexampled swiftness of kindling of the acetylene-oxygen mixture prevented the employment of such burners. There was always striking back of the flame, as the speed of kindling was 1,000 meters, or 3,280 feet, per second. After this, acetylene was employed under high pressure, as with hydrogen and oxygen, but with little success. At last, however, the Fouché burner enabled the employment of acetylene under the ordinary pressure at which it is usually produced.

"In this welding process the acetylene is, with the aid of a very fine injector in the interior of the burner, drawn from the gasometer by the oxygen under a pressure of one to two atmospheres, so that the mixture enters the jet at the required velocity. This is possible only because the oxygen is in greater quantity than the acetylene, the purpose of which is to prevent striking back of the flame.

"One cubic meter = 35.32 cubic feet of acetylene produces in burning 14,340 calories. At the beginning of combustion the acetylene is decomposed into its elements, carbon and hydrogen, and in this dissociation alone it produces 2,600 calories. The rest of the heat is set free by the combustion of the carbon to carbonic acid, and of the hydrogen to water vapor.

"In theory, one volume of acetylene requires for its perfect combustion 2.5 volumes of oxygen. The flame must, however, have a reducing action; there must be for every volume of acetylene 1.7 of oxygen. There thus results a flame composed of an ordinary short blow-pipe flame and a large secondary one. The first one is the place of dissociation of the acetylene into its components. It has a temperature of about 3,000 deg. C., equal to 5,432 deg. F., and consists only of carbonic oxide and pure hydrogen; both of these being reducing gases. With this short flame the welding of the metal is effected without oxidation.

"Welding by acetylene has important advantages over that with hydrogen, as one cubic meter = 35.32 cubic feet of hydrogen produces in burning only 3,091 calories. Therefore we have for acetylene and oxygen: 1 + 1.7 = 2.7 cubic meters, = 14,340 calories in all = 5,238 calories per cubic meter of the gas mixture; for hydrogen and oxygen: 4 + 1 = 5 cubic meters (4× 3,091) = 12,364 calories in all = 2,473 calories per cubic meter of gas mixture; *i. e.*, only about half the results in the first case.

"A further great advantage of the acetylene-oxygen flame is, that the heat is concentrated in a small primary flame, while in the hydrogen-oxygen flame it is more diffused. The heat of the acetylene-oxygen flame is therefore very rapidly given out to the surface to be welded, while the hydrogen and oxygen flame, by reason of its greater size, loses considerably by conduction and radiation.

"The consumption is four volumes of hydrogen, against only 0.59 of acetylene; that is, there is used seven times as much hydrogen as acetylene. But the losses by the oxygen-hydrogen flame are still greater; so that about 1.5 times as much oxygen is necessary as with the acetylene flame. This again increases the hydrogen consumption, so that for the same amount of work about 1.5 times as much oxygen and 10 times as many volumes of hydrogen are required, as where acetylene is used. As the compressed hydrogen costs for freight and other expenses about 1.25 mark per cubic meter, and the acetylene, inclusive of depreciation, only about 1 mark, the saving by the employment of acetylene is very evident. In practice, hydrogen costs from 2 to 10 times as much.

"A complete plant for welding consists of: (1) An acetylene generator; (2) a cylinder of compressed oxygen, with reducing valve; (3) a water seal; and (4) a number of welding burners of different sizes. The acetylene generator must produce clean gas, free from air. Especially to be avoided as impurities are phosphureted and sulphureted hydrogen, as these make the iron 'short.' The oxygen cylinder with

its reducing-valve is exactly the same as for the oxygen-hydrogen process. The water seal is to prevent oxygen getting into the acetylene apparatus in case of any stoppage, as this would form an explosive mixture. The water seal permits the passage of gas in only one direction. The welding burners are made like an injector; that is, the oxygen coming under pressure exhausts the acetylene under a pressure of about 100 millimeters, equaling say 4 inches of water column. The burners are of various sizes, according to what is required of them.

"As regards the cost of the process, it has been shown that with acetylene it is much cheaper than with hydrogen. It is also possible to weld plates of an inch thick with acetylene, which is not possible with hydrogen. The cost per welded seam is about as follows:

Thickness of sheet.	Oxygen.	Acetylene.	Wages.	Total.	
mm.	pf.	pf.	pf.	pf.	cts.
0.5	11	2.5	2.5	5	1.19
1	14	4	3	7	1.67
2	40	10	6	16	3.81
3	82	22	8	30	7.14
4	120	35	12	47	11.19
5	140	37	15	52	12.38
6	210	62	18	80	19.00
8	400	115	25	140	33.30
10	475	140	30	170	40.50
12	800	250	40	290	69.00

"The cost per seam depends naturally somewhat on the ability of the workmen. The acetylene process of welding is, however, easily learned, and the workman soon is enabled to make seams that are as strong as the solid metal. In any case, such a seam is better than a riveted or brazed one.

"As regards the heat of the flame, there is hardly any material that can withstand it. Brick, pumice-stone, the so-called fireproof brick, even carbide, which is made at a temperature of 3,000 deg. C. (5,432 deg. F.) is melted in a moment; graphite is the only thing that will stand up under it.

"In France there were, at the time this paper was prepared, over 800 firms employing this process. Among the various applications of the process may be mentioned:

(*a*) Welding iron or copper up to an inch thick.

(1) Replacing riveting for thin sheets.

(2) Replacing soldering and brazing.

(3) Making boilers and reservoirs, and repairing such, up to an inch plate-thickness.

(4) Welding together angle iron and profile iron.

(5) Manufacture of tubes in all dimensions, making both lengthwise and end joints.

(*b*) Welding flanges, pipe, nozzles, etc., whether the material be iron, copper, brass or what not.

(*c*) Making steel castings, malleable iron, bronze or brass castings.

(*d*) Repairing fractures in cast iron retorts, faults in general, and in automobile and bicycle manufacture; doing away with all rivets, bolts, screws, and making the frames in one piece.

(*e*) General industry—all sorts of repairs, making endless pipe-lines, etc.

(*f*) In mechanical and electric construction works, where several pieces are to be united, even where they are of different metals; as for instance in dynamo armatures, and in making joints in conductors.

(*g*) In ornamental forging, the manufacture of burglar-proof safes, and the manufacture of sheet-iron ware, either enameled or not.

(*h*) Welding band-saw blades.

(*i*) Manufacture of articles for the army.

(*j*) Making cannon, side-arms, etc.

(*k*) Mending shovels or spades, hoes, forks, etc.

(*l*) Repairing gear-wheels of steel, brass, or cast iron.

(*m*) In locomotive building and narrow-gage railway building and in shipyards.

(*n*) Construction of iron ships and motor boats, and repairing boilers on board.

(*o*) Manufacture of iron vessels.

(*p*) Manufacture of steel heaters.

(*q*) Manufacture of iron window-frames.

Also, in any machine shop or establishment where machinery is used, broken parts may be repaired in place. . . . .

"The oxygen-acetylene process is cheaper to work than any other method of welding, and the cost for plant is comparatively low. It is advantageous even for very small transportable plants, as there may be used an acetylene apparatus not larger than a hydrogen cylinder. For large and very large establishments it is possible, and also advantageous, to make the oxygen in the establishment itself, which brings the price down to one-tenth of that where it must be bought."

MOTOR BUSES IN NEW YORK CITY.

DETAILS OF THE DE DION-BOUTON GASOLENE CARS IN SERVICE ON FIFTH AVENUE, NEW YORK CITY.

Street Railway Journal.

FIFTH Avenue, New York City, is closed to street-car traffic but has had, for a number of years, an omnibus service. Until recently the buses were drawn by horses, but about a year ago the company operating the service began to experiment with motor buses. An order was recently placed for fifteen De Dion-Bouton gasolene cars which are now in service and giving excellent satisfaction. The following details of these cars is taken from the *Street Railway Journal.*

"The body is of the typical 'London Road Car' type, having longitudinal seats inside with a capacity for sixteen passengers, and transverse seats on the top, seating eighteen passengers. The end windows are removable; the side windows are permanently closed, ventilation being obtained by louvers and small ventilating windows in the sides over the large windows. The winding stairway is of very light sheet steel and wood construction, protected by a high railing to prevent accident in case the bus should start suddenly. The body is easily removable, having no connection whatever with any part of mechanism, brake rods, etc., and being fastened to members of the frame with eight carriage bolts.

"The engine is rated at 24 horsepower capacity of the four-cylinder vertical type, with 105 x 130-millimetre cylinders, automatic inlet valves, high-tension ignition, with high-tension distributor and single non-trembling coil, working either from the magneto or dry cells by a two-way switch. The water circulation is by a centrifugal pump driven by a flexible shaft. The carburetor is automatic and heated by shunt pipe from the circulating water. The radiator is of the honeycomb type, having a large capacity and good efficiency. The lubrication is entirely automatic, the oil being forced by a positive gear pump through the crankshaft, which has an oil passage drilled through it, the oil being fed through small holes to the main bearings, crank pins, magneto and pump spindles. After passing through the bearings the oil drops to the crank case and through a filter to the main oil reservoir which supplies the pump. The consumption of oil is very slight, as the bearings are so constructed as to prevent any oil escaping; the only loss is due to carbonization in the cylinders. The latter are protected from excessive supply of oil by baffle-plates, so that the exhaust is never smoky, nor do the cylinder walls, valves and spark plugs become coated with carbonized oil.

"The gear box is of the sliding-gear type, having four gear ratios and a progressive engagement of gears. The gears are very light and of comparatively small diameter, but this is admissible owing to the large reduction of gear ratio between the driving pinions and the internal toothed driving rings on rear wheels; that is, the gears run at high speed and are subjected to comparatively small torsional stresses and toothed contact pressures. The gears are made of chrome nickel steel, and after four months' operation show no signs of wear. The differential gear and countershaft are incorporated in the gear box, thus conducing to compactness and efficiency, owing to the elimination of extra bearings. The lubrication of the gears is by a gear oil pump fitted to the bottom of the gear box, similar to the one used on the engine, this pump delivering oil to all the bearings and also to a pipe parallel to the gear-shaft and located directly above it. This pipe is provided with holes directly above each of the gears. A constant stream of oil is thus playing upon the latter at all times when the vehicle is in motion, and practically no oil is lost, as special means are provided to prevent its escape.

"The machine is extremely easy to control: two pedals are provided, the right one being the clutch pedal, and the left one actuating the differential hand brake and also closing the throttle. A change-speed lever and an emergency brake are at the right of the driver. Either the differential brake or hand brake will lock the rear

wheels on asphalt. The clutch, which is of the single disc metal-to-metal type, is extremely smooth and easy in engagement, and the bus can be started on the top speed owing to the gradual way in which the clutch picks up the load. It runs in oil and is subject to very little wear, although automatic compensation is provided for it. When driving in traffic it is not necessary for the operator to remove either of his hands from the steering wheel, as the clutch, throttle and brake can be operated with his feet. The bus complete with water and fuel weighs 7,900 pounds, increased when loaded to 13,000 pounds. The speed is 12 miles per hour on top speed at 1,000 revolutions per minute. This engine speed can be safely increased to 1,250 revolutions per minute, equivalent to 15½ miles per hour."

WEALTH AND WAGE EARNERS.

A DISCUSSION OF THE RELATIVE EARNINGS OF CAPITAL AND LABOR.

Engineering News.

THE following abstract of an editorial in a recent number of *Engineering News* contains a notable refutation of the Socialist doctrine that vast accumulation and concentration of wealth constitute a public danger. The Socialist aims at a redistribution of wealth, holding that the earnings of capital so far exceed those of labor as to impose an undue burden upon production, a burden the removal of which would result in a vast improvement of the welfare of the people as a whole. But the Socialist bases his opinion on the superficial evidences of wealth, on the rapid increase in the number of multi-millionaires and of families who lavish large sums of money on ostentatious display. This illuminating presentation of the concrete facts of the case shows clearly the fallacy of the Socialistic premis, that the earnings of capital are largely in excess of those of labor, and that an arbitrary redistribution of wealth involving the overthrow of all economic laws, would improve the condition of labor.

"To a certain extent the question raised by the Socialist is a fair one and deserves fair investigation and an honest answer. Is the rapid increase of wealth a threat against the welfare of the people as a whole? If we concede, for the sake of argument, that payments for the use of capital are a burden—a fixed charge—upon production, it is reasonable to inquire how great has this burden become?

"The United States Census Bureau has recently issued a volume containing information which, it seems to us, may be fairly made use of to test the claims of socialism. The volume is entitled "Wealth, Debt and Taxation." It gives what is doubtless the most accurate and careful estimate ever made of the total wealth of the United States. The estimate is made for the year 1900 and the year 1904. In the former year the total value of all property in the United States is set at $88,500,000,000. In the latter year the total was $107,000,000,000.

"These figures by themselves mean nothing. They are too huge for comprehension. But if it were possible to draw from them an approximate estimate of the total income which capital, or accumulated wealth, receives, and if we could then compare this income with the total earnings of labor, the comparison might contain some useful lessons.

"Let us take first the task of estimating the total income which capital receives. The census report before us classes the total wealth of the United States as follows:

Real property and improvements	$62,341,000,000
Live stock	4,074,000,000
Farm implements and machinery	845,000,000
Manufacturing machinery, tools and implements	3,300,000,000
Gold and silver coin and bullion	2,000,000,000
Railroads and their equipment	11,245,000,000
Street railways, shipping, waterworks, electric light and power systems, telegraph and telephone systems, and canals	4,841,000,000
All other property — products of agriculture, manufactures and mines, merchandise, clothing, furniture, carriages, and miscellaneous personal property	18,462,000,000

In the first place it must be recognized that not all the wealth in the above table yields any income. The personal property included in the last item is uninvested wealth and yields no income. Likewise the

list includes all property belonging to the Government, states, cities and counties. This property, including churches, hospitals, schools, etc., is held for the public benefit and where it produces any income, that income belongs to the public and returns directly to them.

"The total amount of this public property, according to the census schedule, is $7,830,000,000. Adding this to the $18,462,000,000 worth of personal effects, we have $26,292,000,000 to be deducted from the total of $107,104,000,000, leaving $80,812,000,000 as the amount of possible income-producing wealth in the United States. Undoubtedly much of this property also produces no income, and much more produces very small returns; on the other hand this is offset by other property which yields large returns. In estimating this average rate of income yielded by property, we may well be guided by the returns on railway property since in that field the accurate statistics of the Interstate Commerce Commission are available. In 1904 the railways of the United States paid to their owners, the railway stock and bond holders, in interest and dividends the sum of $480,000,000 in round numbers, which was an average of 4¼ per cent. on the value of the railways given above.

"It is doubtful whether real estate, which is seen above to constitute the bulk of the property of the United States, would show anything like as large an average return as the railways; but as we are aiming to find the maximum possible drain that capital may be making on the country, we will assume that railway capital represents a fair average of the rate of income produced by all wealth. On this basis $80,812,000,000 of invested capital at 4¼ per cent. would yield an annual return of $3,534,000,000.

"And now let us turn and study the side of labor. The population of the United States on June 1, 1904, is placed by the census at 81,256,000. It was 76,000,000 in round numbers in 1900. The number of wage earners, or 'persons engaged in gainful occupations,' was given by the census of 1900 as 29,286,000. At the present time, therefore, this number must be swelled to some 31,000,000. We believe, however, that this is in excess of the true number of wage workers, as it includes those who are past the age of active work and those who are incapacitated for other reasons. A more accurate method, we believe, is to estimate one worker to each 3½ persons, which would give a total of 23,200,000 wage earners in round numbers.

"What are the average annual earnings of these workers? For a guide in answering this question we turn again to the Interstate Commerce Commission railway statistics, and find there that in 1905 there were 1,382,000 men employed on the railways of the United States who received wages and salaries amounting to 840 million dollars, or an average of $608 per employee. Again, the Census report on Manufactures just issued shows that in 1905 there were in round numbers 6,000,000 persons engaged in manufacturing industries who received wages and salaries amounting to $3,186,000,000, or an average of $531 each. Similar statistics are not available for other occupations; but it will probably be generally agreed that the 1½ million persons engaged in professional occupations receive a higher average than this, while the 10½ millions engaged in agricultural and the 5½ in domestic and personal service receive considerably less. All things considered, $450 per annum seems as low a figure as can reasonably be estimated as the earnings of the average worker.

"Multiplying now the total number of wage earners found by these average earnings, we have the total compensation paid to labor in a year at $10,340,000,000.

"If these figures be accepted, then it appears that capital is now receiving about one dollar where labor is receiving three; or, to put it another way, if the annual product of the country is divided into four equal heaps, capital is getting one of these heaps and labor the other three.

"This conclusion can be substantiated, however, in other ways. Everyone familiar with business affairs knows that in almost every industry the annual pay roll is several times as large as the amount which the owners of the business can draw out in profits. In the railway industry exact statistics are available and were quoted above, viz., annual payments to security holders of $480,000,000 compared with an-

nual payments of 840 million dollars. Here the proportion is slightly less than 1 to 2; but in railway transportation there is a larger investment of fixed capital required per employee than in almost any other industry. The figures above given were: Capital in railways, $11,245,000,000; number of employees, 1,382,000; average investment per employee, $8,140. In contrast with this are the conditions in agriculture where two or three men are required to do the work on a farm worth perhaps $5,000. Remembering that some ten millions of the wage earners of the country are engaged in agriculture, it is an inevitable conclusion that our estimate of 1 to 3 as the proportional distribution to capital and to labor errs if anything by giving a larger return to capital than it actually receives."

In making comparisons between the earnings of capital and the earnings of labor, a common error is to confound capital with wealth and labor with poverty. A large part of the total wealth of the United States is the property of the wage earners themselves. The huge fortunes of the multi-millionaires are in bulk much less than the accumulated savings of people of moderate means. The $3,482,000,000 deposited in the savings banks, the $2,700,000,000 assets of the life insurance companies, and the $16,615,000,000 worth of farm property all represent widely-distributed wealth belonging to the latter class in which the Socialist can surely see no menace to public welfare. To give the Socialist, however, every chance to prove his claims, let it be supposed that all existing wealth is confiscated and distributed among all wage earners, that under those circumstances it would be as productive of income as at present, and that the workers in the revolutionized social order could reap the same return as now in the shape of wages. The result would be that the average wage earner who now has an income of $450 per annum would receive about $150 additional, an increase which could neither make everybody wealthy, nor abolish poverty, but could only to a very slight degree lighten the task of the worker or increase his comforts.

ABSTRACT SCIENCE AND ENGINEERING.

THE INFLUENCE OF THE INDUSTRIAL DEVELOPMENT OF SCIENTIFIC PRINCIPLES ON THE PROGRESS OF PURE SCIENCE.

Prof. Silvanus P. Thompson—British Association for the Advancement of Science.

PROF. S. P. Thompson's recent presidential address before the Engineering Section of the British Association for the Advancement of Science discussed in a very interesting manner the relation between abstract science and engineering. Touching first upon the vast development of the material resources of civilization, the rapidity of its progress, and the absolute dependence of the whole upon science, directed mainly by the engineer, Prof. Thompson developed his theme along novel lines. The influence of abstract science upon engineering and industrial progress has often been discussed, but very little attention has been paid to the influence of the industrial applications of scientific principles upon the development of abstract science itself. It is to the latter that Prof. Thompson devotes the greater part of his address and the following extracts give an outline of his argument.

"In engineering, above all other branches of human effort, we are able to trace the close interaction between abstract science and its practical applications. Often as the connection between pure science and its applications has been emphasised in addresses upon engineering, the emphasis has almost always been laid upon the influence of the abstract upon the concrete. We are all familiar with the doctrine that the progress of science ought to be an end in itself, that scientific research ought to be pursued without regard to its immediate applications, that the importance of a discovery must not be measured by its apparent utility at the moment. We are assured that research in pure science is bound to work itself out in due time into technical applications of utility, and that the pioneer ought not to pause in his quest to work out potential industrial developments. We are invited to consider the example of the immortal Fara-

day, who deliberately abstained from busying himself with marketable inventions arising out of his discoveries, excusing himself on the ground that he had no time to spare for money-making. It is equally true, and equally to the point, that Faraday, when he had established a new fact or a new physical relation, ceased from busying himself with it, and pronounced that it was now ready to be handed over to the mathematicians. But, admitting all these commonplaces as to the value of abstract science in itself and for its own sake, admitting also, the proposition that sooner or later the practical applications are bound to follow upon the discovery, it yet remains true that in this thing the temperament of the discoverer counts for something. There are scientific investigators who cannot pursue their work if troubled by the question of ulterior applications; there are others no less truly scientific who simply cannot work without the definiteness of aim that is given by a practical problem awaiting solution. There are Willanses as well as Regnaults; there are Whitworths as well as Poissons. The world needs both types of investigator; and it needs, too, yet another type of pioneer—namely, the man who, making no claim to original discovery, by patient application and intelligent skill turns to industrial fruitfulness the results already attained in abstract discovery.

"There is, however, another aspect of the relation between pure and applied science, the significance of which has not been hitherto so much emphasised, but yet is none the less real—the reaction upon science and upon scientific discovery of the industrial applications. For while pure science breeds useful inventions, it is none the less true that the industrial development of useful inventions fosters the progress of pure science. No one who is conversant with the history, for example, of optics can doubt that the invention of the telescope and the desire to perfect it were the principal factors in the outburst of optical science which we associate with the names of Newton, Huygens, and Euler. The practical application, which we know was in the minds of each of these men, must surely have been the impelling motive that caused them to concentrate on abstract optics their great and exceptional powers of thought. It was in the quest—the hopeless quest—of the philosopher's stone and the elixir of life that the foundations of the science of chemistry were laid. The invention of the art of photography has given immense assistance to sciences as widely apart as meteorology, ethnology, astronomy, zoology, and spectroscopy. Of the laws of heat men were profoundly ignorant until the invention of the steam-engine compelled scientific investigation; and the new science of thermodynamics was born. Had there been no industrial development of the steam-engine, is it at all likely that the world would ever have been enriched with the scientific researches of Rankine, Joule, Regnault, Hirn, or James Thomson? The magnet had been known for centuries, yet the study of it was utterly neglected until the application of it in the mariners' compass gave the incentive for research.

"The history of electric telegraphy furnishes a very striking example of this reflex influence of industrial applications. The discovery of the electric current by Volta and the investigation of its properties appear to have been stimulated by the medical properties attributed in the preceding 50 years to electric discharges. But, once the current had been discovered, a new incentive arose in the dim possibility it suggested of transmitting signals to a distance. This was certainly a possibility, even when only the chemical effects of the current had yet been found out. Not, however, until the magnetic effects of the current had been discovered and investigated did telegraphy assume commercial shape at the hands of Cooke and Wheatstone in England and of Morse and Vail in America. Let us admit freely that these men were inventors rather than discoverers: exploiters of research rather than pioneers. They built upon the foundations laid by Volta, Oersted, Sturgeon, Henry, and a host of less famous workers. But no sooner had the telegraph become of industrial importance, with telegraph lines erected on land and submarine cables laid in the sea, than fresh investigations were found necessary. New and delicate instruments must be devised, means of accurate measurement heretofore undreamed of must be found, standards for the comparison of electrical quantities must be created, and the laws governing the op-

erations of electrical systems and apparatus must be investigated and formulated in appropriate mathematical expressions. And so, perforce, as the inevitable consequence of the growth of the telegraph industry, and mainly at the hands of those interested in submarine telegraphy, there came about the system of electrical and electromagnetic units, based on the early magnetic work of Gauss and Weber, developed further by Lord Kelvin, by Bright and Clark, and last, but not least, by Clerk Maxwell. Had there been no telegraph industry to force electrical measurement and electrical theory to the front, where would Clerk Maxwell's work have been? He would probably have given his unique powers to the study of optics or geometry; his electromagnetic theory of light would never have leapt into his brain; he would never have propounded the existence of electric waves in the ether. And then we should never have had the far-reaching investigations of Heinrich Hertz; nor would the Britisn Association at Oxford in 1894 have witnessed the demonstration of wireless telegraphy by Sir Oliver Lodge. A remark of Lord Rayleigh's may here be recalled, that the invention of the telephone had probably done more than anything else to make electricians understand the principle of self-induction.

"In considering this reflex influence of the industrial applications upon the progress of pure science it is of some significance to note that, for the most part, this influence is entirely helpful. There may be sporadic cases where industrial conditions tend temporarily to check progress by imposing persistence of a particular type of machine or appliance; but the general trend is always to help to new developments. The reaction aids the action; the law that is true enough in inorganic conservative systems, that reaction opposes the action, ceases here to be applicable, as indeed it ceases to be applicable in a vast number of organic phenomena. It is the very instability thereby introduced which is the essential of progress. The growing organism acts on its environment, and the change in the environment reacts on the organism—not in such a way as to oppose the growth, but so as to promote it. So it is with the development of pure science and its practical applications.

"In further illustration of this principle one might refer to the immense effect which the engineering use of steel has had upon the study of the chemistry of the alloys. And the study of the alloys has in turn led to the recent development of metallography. It would even seem that through the study of the intimate structure of metals, prompted by the needs of engineers, we are within measurable distance of arriving at a knowledge of the secret of crystallogenesis. Everything points to a very great and rapid advance in that fascinating branch of pure science at no distant date."

THE PUPIN TELEPHONE CABLE OF THE LAKE OF CONSTANCE.

A DESCRIPTION OF THE FIRST SUBMARINE TELEPHONE CABLE ON THE PUPIN SYSTEM, RECENTLY LAID IN THE BODENSEE.

Engineering—Elektrotechnische Zeitschrift.

A RECENT number of *Engineering* contains an interesting discussion of the problem of submarine telephone communication over long distances, and a description of the first submarine cable on the Pupin system, which was recently laid in the Lake of Constance. The latter part of the article is largely drawn from a paper by Dr. Ebeling, published recently in *Elektrotechnische Zeitschrift.*

"Considering that we have had submarine telegraph cables for half a century, the small number of submarine telephone cables may be a matter of surprise to the non-technical public. There is, however, a special difficulty as to the submarine telephone cable. Owing to its construction the telephone cable has greater capacity and smaller inductance than a land line of corresponding resistance and length. But we know, from the researches of Oliver Heaviside, that in order to obtain clear speech, we should have small capacity and high self-induction. Where we are not confronted with insulation troubles, the two conditions may easily be combined. For

submarine cables gutta-percha has generally been considered the best insulating material, in spite of its high price and its high inductive capacity. Vulcanised rubber may be used, and has, indeed, answered in a few of the submarine cables of the early days. But rubber is not generally trusted, and air space and paper insulation, so useful and convenient in many instances, and of small inductive capacity, are difficult of application in submarine cables, because we have to provide a suitable impervious sheath, which will also bear a great water pressure.

"If it were not for these mechanical difficulties, the experimental verification by Pupin of Heaviside's deductions should long ago have helped us to long-distance submarine telephone cables. Pupin showed that by adding self-inductance to the line at intervals we can greatly increase the range of clear speech. Long lines of high, or of moderate, capacity exert a damping influence upon the high-frequency alternating-current waves passing through a telephone line. The damping depends upon the capacity, inductance, resistance, length, and leakage of the line—a certain leakage does not do any harm—and the frequency of the currents, and that term of the function, which is more particularly known as the Pupin constant β represents a numerical factor which teaches us over what length of line speech may be possible, or what values must be given to the chief factors—resistance, capacity, and inductance—in order to render speech feasible. When the inductance is very high, waves of all periods will practically be damped to the same amount, and the sounds will be reproduced weakened, but with their natural tones. When the inductance is very small, on the other hand, the overtones and the hissing sounds will be damped, and we obtain loud, but indistinct sounds. The inductance can be increased by enlarging the copper core, when the capacity will likewise rise, however. This arrangement was tried on the English-Belgian cable, laid before these problems were clearly understood. The core was made thick to decrease the ohmic resistance, and the capacity was decreased by increasing the thickness of the gutta-percha. In the English-French cable the capacity was reduced by providing the four cores with a common gutta-percha sheath. All these early cables contain four symmetrically grouped cores to prevent mutual interference between the two pairs.

"When, in 1902, an improved telephone service was wanted between North Germany and Denmark, and also between Cuxhaven and Heligoland, telephone-cable manufacturers were not prepared to supply submarine Pupin cables, with self-inductance inserted at intervals, although land cables of this type had been laid. In 1899, Breisig, of Berlin, showed that the inductance of a cable could also be increased by coiling iron tape in a spiral round the core, over its full length, and later on the Danish engineer Krarup proved that fine iron wire wound directly on the copper core would serve the same purpose. The iron wire need not be insulated from the copper, which may be varnished. Krarup's suggestion was adopted by Messrs. Felten and Guilleaume in the cables of 1903, which were laid in depths of about 20 metres.

"In the four-core Fehmarn-Laalland cable, each of the seven copper strands, of 1.35 millimetres, is coiled with bare iron wire of 0.3 millimetre; over this are placed the impregnated paper insulation, jute, two lead sheaths, compound, and an iron wire armouring. The Cuxhaven-Heligoland cable, 75 kilometres (47) miles in length, is similarly constructed; the Refsnaes-Soelvig cable, laid about the same time, is a gutta-percha cable.

"The comparative weights (in kilogrammes per metre) and total costs (marks or shillings per metre) of some of these cables have been estimated by Breisig as follows:

	Marks.
English-Belgian cable—7.2 kilog.....	6.78
Greetsiel-Borkum cable—6.8 kilog...	4.78
Heligoland cable—8.5 kilog.....	6.38

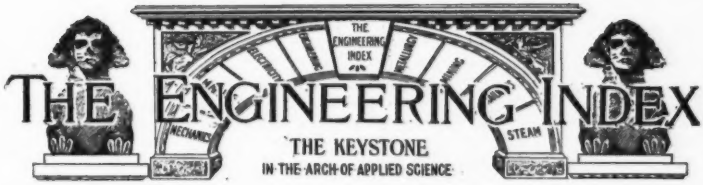
"The Greetsiel-Borkum cable (30 kilometres, or nearly 20 miles in length) which is also one of the Felten and Guilleaume cables of 1903, has only half the damping constant of the English-Belgian cable—an important point for cables joined to long land lines—and was considerably cheaper, it will be seen.

"In none of the cases so far mentioned, however, did the depth of the water ex-

ceed 40 metres. The case of the Bodensee cable, laid by Messrs. Siemens and Halske in 1906, was different. The depth of the open lake portion between Friedrichshafen (in Württemberg) and Romanshorn (in Switzerland) is 250 metres (820 ft.), and considerable difficulties have been encountered, although the length of the cable is only 12 kilometres (7.5 miles). Dr. Ebeling's explanation of the difficulties and temporary failures, which he gave in his account of the manufacture and laying of this cable delivered before a recent meeting of the Elektrotechnische Verein, was particularly interesting. It is the first submarine telephone cable on the Pupin system, the self-inductance of coiled iron wire being inserted at intervals of 1 kilometre; calculations as to the number and distribution of the induction coils required for particular purposes were given by Breisig in 1904. The cable comprises seven complete circuits.

"As the water pressure is 25 atmospheres at a depth of 250 metres, experiments were made as to the strength of the cables, and the pressure was in these experiments raised to 150 atmospheres in order to make sure that an apparently harmless pressure might not prove injurious in the course of time. The cables, provided with a double lead sheath of 5 millimetres (0.2 in.) thickness, were all crushed; a pressure of 50 atmospheres would, for instance, flatten out in two hours cables which had borne that pressure quite well for half an hour. The ordinary armouring could not prevent the crushing; but a remedy was found by coiling a steel wire of 2 millimetres thickness in a spiral round the paper insulation, the spirals being 5 millimetres or more apart. It was desired to divide the insulation into water-tight sections by inserting impervious portions in the middle, between the inductance coils. Originally the cable was made as lead cable in lengths of 500 metres, and either an inductance coil or a section insulator were alternately interposed between the different lengths. These parts were thicker than the cable itself. The iron wire coil was common to the seven circuits, and formed a cylindrical portion of larger diameter; a section insulator formed a doubly conical piece. The armouring was continuous all over the cable, and over those thicker portions. When the laying of the cable was commenced in the autumn of 1905, however, one of the splices failed almost at the beginning, and as the season was advanced, the laying was put off till the following summer, and certain alterations were made in the cable. The alteration concerned the coils and section insulators, which are now combined. The inductance now consists, as before, and as in the cables we have mentioned, of iron wire; but the wire is coiled in alternating sections round three or four of the seven pairs of lines. The coil itself is cylindrical; the larger diameter of this cylinder is then brought down to the smaller diameter of the cores by two conical portions; and these conical portions are the waterproof seals between different cable sections. The lead sheath is, in the conical portion, supported by a conical wire spiral, and the paper insulation is replaced by gutta-percha. These repairs had to be executed on the lake shore, and the cable armouring was applied by hand while the cable was kept under a tension of 2 tons. During these repairs the method of splicing was also perfected; in the case just referred to the lead sheathing had burst over a splice. . . . . .

"As regards the cable, the size of a copper strand corresponds to a diameter of 1.5 millimetre. The resistance of 1 kilometre of double line was limited by contract to 20 ohms, the total resistance to 40 ohms, and the actual resistance is 33.5 ohms. The capacity is 0.039 microfarad per kilometre, against 0.05 of the contract; the inductance, 0.21 henry, against 0.20; and the Pupin damping constant 0.0072, against 0.01. The Pupin constant is almost as small as in the case of the Heligoland cable, where it is 0.0065; but the copper diameter of this latter cable is 4 millimetres, and its resistance 3.8 ohms, so that almost as good a damping has been attained in the Pupin cable with only one-seventh of the cross section of copper. This is a very important gain. No doubt the telephone cable lying in the Lake of Constance has been costly, but we know now that submarine Pupin cables can be made, and how they are to be made, and the ordinary scale of expenditure must not be applied to pioneer work."



The following pages form a descriptive index to the important articles of permanent value published currently in about two hundred of the leading engineering journals of the world—in English, French, German, Dutch, Italian, and Spanish, together with the published transactions of important engineering societies in the principal countries. It will be observed that each index note gives the following essential information about every publication:

(1) The title of each article,
(2) The name of its author,
(3) A descriptive abstract,
(4) Its length in words,
(5) Where published,
(6) When published,

(7) *We supply the articles themselves, if desired.*

The Index is conveniently classified into the larger divisions of engineering science, to the end that the busy engineer, superintendent or works manager may quickly turn to what concerns himself and his special branches of work. By this means it is possible within a few minutes' time each month to learn promptly of every important article, published anywhere in the world, upon the subjects claiming one's special interest.

The full text of every article referred to in the Index, together with all illustrations, can usually be supplied by us. See the "Explanatory Note" at the end, where also the full title of the principal journals indexed are given.

DIVISIONS OF THE ENGINEERING INDEX.

Civil Engineering	203	Mechanical Engineering	217
Electrical Engineering	209	Mining and Metallurgy	227
Industrial Economy	214	Railway Engineering	233
Marine and Naval Engineering	215	Street and Electric Railways	237

CIVIL ENGINEERING

BRIDGES.

Bascule.

New Bascule Bridge at Duisbourg. Illustrated detailed description of a new bridge costing approximately £24,465. 1200 w. Engr, Lond—Aug. 9, 1907. No. 86474 A.

Blackwell's Island.

The Erection of the Blackwell's Island Bridge. Illustrations, with brief account of the erection of the new cantilever bridge over the East River, at New York. 1600 w. Sci Am—Aug. 10, 1907. No. 86303.

Centering.

Moving the Centering of the Walnut Lane Arch at Philadelphia. Illustrates and describes the method of moving the centering from the finished ring to its position under the twin ring. 600 w. Eng News—Aug. 15, 1907. No. 86394.

Failure.

Failure of Masonry Arch Carrying Erie Canal Over Onondaga Creek, Syra-

We supply copies of these articles. See page 239.

cuse, N. Y. An illustrated account of the collapse on July 30, which has closed the canal to through traffic in one of its busiest seasons. 1700 w. Eng News—Aug. 8, 1907. No. 86313.

Highway Bridge.

Economical Methods of Highway Bridge Construction. Describes wooden falsework adjustable to different heights and adapted to be used over and over again for successive bridge. Ills. 2000 w. Eng Rec—Aug. 24, 1907. No. 86563.

Plate Girder.

A Plate Girder Highwav Arch Bridge. Illustrated description of a bridge in Princeton, N. J., consisting of four three-hinge plate girder arch spans. 900 w. Eng Rec—Aug. 17, 1907. No. 86421.

Removals.

Removing a Stone Arch Bridge Over the Northern Railway of France. Illustrates and describes methods used under difficult conditions. 800 w. Eng News—Aug. 1, 1907. No. 86078.

Steel.

The New Railway Bridge over the Neckar at Heidelberg (Die Neue Eisenbahnbrücke über den Neckar bei Heidelberg). G. Lucas, D. R. Müller and G. Trauer. The first part of the serial describes the foundation work for this four-span steel structure. Ills. 1000 w. Serial. 1st part. Deutsche Bau—July 6, 1907. No. 86253 D.

Steel Designing.

The Proportioning of Steel Railway Bridge Members. Henry S. Prichard. Discusses the strength of structural steel, safe working stresses, rules for designing compression members, and provisions for live loads. 9500 w. Pro Engrs' Soc of W Penn—July, 1907. No. 86398 D.

Swing Bridge.

The Double-Deck Swing Bridge at the Upper Harbor at Hamburg (Pont Tournant à deux Etages sur le Port Supérieur de Hambourg). A. Bidault des Chaumes. Illustrated description of this large steel bridge, the upper deck of which carries four lines of rails and the lower is arranged for vehicular and foot traffic. 3000 w. Génie Civil—July 6, 1907. No. 86209 D.

Trestles.

A Pile Trestle Erected with a Pivotal Pile-Driver. R. Balfour. Illustrates and describes a pivotal pile-driver and its use. 1000 w. Eng News—Aug. 15, 1907. No. 86389.

Viaducts.

Armored Concrete Viaduct at Deurne-Merxem. Illustrated detailed description of a structure near Antwerp, constructed on the Hennebique system. 2500 w. Engr, Lond—Aug. 16, 1907. No. 86603 A.

Curved Girder Approach Viaduct of the Austerlitz Bridge Over the Seine. R. Bonnin. A statement of the essential difference between the curved girder and the straight girder, pointing out the additional forces to which the former is subjected. An appendix gives a general theory of curved girders. Ills. 2000 w. Eng News—Aug. 15, 1907. No. 86386.

Wooden Truss.

Early Wooden Bridges. Illustrates and describes early forms of wooden bridges. The Burr bridge, the Howe truss bridge, etc. 800 w. Ry & Loc Eng—Aug., 1907. No. 86043 C.

CONSTRUCTION.

Arches.

The Application of the Elastic Theory to Certain Forms of Arch. A letter from R. C. Barnett on the application of the elastic theory to arch analysis. 1200 w. Eng News—Aug. 1, 1907. No. 86080.

Breakwaters.

Stone Breakwater Construction at Huron, Ohio. Wilson T. Howe. Describes an example of the modification that has taken place in stone breakwater construction. Ills. 1000 w. Eng News—Aug. 22, 1907. No. 86508.

Buildings.

The Design and Construction of Industrial Buildings. D. C. Newman Collins. An illustrated article discussing materials and methods representing the most recent practice. 7000 w. Engineering Magazine —Sept., 1907. No. 86610 B.

The Calvary Cemetery Mortuary Chapel. A structure to cost about $200,000, mainly of concrete construction, and having architectural features of interest is illustrated and described. 1500 w. Eng Rec—Aug. 3, 1907. No. 86090.

The Hudson Companies' Building, New York. Plans and description of construction details of this large terminal station, occupying two city blocks in New York. 2500 w. Eng Rec—Aug. 3, 1907. No. 86088.

Building Details.

The Construction of the New York Central Office Building, New York. Describes a steel-cage, fire-proof, 20-story building of special design. Ills. 2500 w. Eng Rec—Aug. 24, 1907. No. 86557.

Concrete.

The Chateau des Beaux-Arts on Huntington Bay. Illustrated description of extensive use of concrete in the construction of a summer resort on the south shore of Long Island. 3000 w. Eng Rec —Aug. 17, 1907. No. 86423.

Contracts.

Engineers' Contracts and Specifications from a Contractor's Point of View. James W. Rollins, Jr. Especially discusses the contract as a mutual understanding, and the troubles arising on account of badly-

We supply copies of these articles. See page 239.

drawn specifications. General discussion. 25000 w. Jour Assn of Engng Socs—July, 1907. No. 86395 C.

Dams.

A Buttressed Concrete Dam. A stone dam at Matteawan, N. Y., raised 7 ft. by an addition of buttressed concrete is illustrated and described. 2000 w. Eng Rec—Aug. 24, 1907. No. 86562.

Movable Crest Dams at the Water Power Development of the Chicago Drainage Canal. Illustrated detailed description of movable crests of structural steel and steel plates, designed to furnish a passage for all drift which cannot safely pass through the water turbines. 3500 w. Eng Rec—Aug. 24, 1907. No. 86555.

Reconstructing a Masonry Dam for Increased Depth of Storage. An unusual piece of dam-building, near Lennep, Germany, in connection with the water supply system, is illustrated and described. 600 w. Eng News—Aug. 29, 1907. No. 86629.

Specifications for the Main Dams, Ashokan Reservoir, New York City Water Supply. Gives sections from the specifications, with illustrations and explanatory notes, for a high masonry dam with earth wings. 2000 w. Eng News—Aug. 1, 1907. No. 86074.

The Construction of the Dam of the Nevada-California Power Co. Describes a dam to be built of loose rock puddled on the upper side, across a narrow valley at a high altitude in the Sierra Nevada Mts. Ills. 1200 w. Eng Rec—Aug. 3, 1907. No. 86092.

Excavation.

Retaining the Sides of a large Excavation. Illustrated description of sheeting and bracing used for the Swift & Co. building in New York City, where the excavation was through a deep stratum of fine sand and quicksand, with abundance of ground water. 1500 w. Eng Rec—Aug. 24, 1907. No. 86556.

Failure.

Collapse of Reinforced Concrete Building in Philadelphia. Gives the opinions of engineers, and the views of the coroner's jury as to the cause of failure, with editorial. Ills. 4500 w. Cement Age—Aug., 1907. No. 86482.

Floors.

Economics of Reinforced Concrete Floor Slabs. A. E. Budell. A comparison between the actual cost of the slab floor and the combination tile and beam system. Ills. 800 w. Engng-Con—Aug. 14, 1907. No. 86405.

Foundations.

Notes on Foundations. Discusses the requisites of a good foundation, and the processes used in excavating. 2500 w. Can Archt—Aug., 1907. No. 86572 C.

Ice Problem.

The Ice Problem in Engineering Work in Canada. Howard T. Barnes. Read before the British Assn. An explanation of conditions in the Canadian streams during winter, and some of the means of overcoming difficulties. 2000 w. Engng—Aug. 9, 1907. No. 86471 A.

Pier Failure.

The Locust Point Pier Collapse in Baltimore. Photographs of the wrecked pier with an explanation of the probable cause of the collapse. 600 w. Eng News—Aug. 8, 1907. No. 86307.

Reinforced Concrete.

Design of Reinforced Concrete Structures—Flat Top Culverts. Walter W. Colpitts. The present article discusses the design of flat top culverts on the Kansas City Outer Belt & Electric R. R. 2800 w. Ry Age—Aug. 16, 1907. Serial. 1st part. No. 86438.

Design of Reinforced Concrete Structures—Abutments. Walter W. Colpitts. Describes in detail the design of reinforced concrete abutments adopted by the Kansas City, Mexico, and Orient Ry. Ills. 2500 w. Ry Age—Aug. 23, 1907. No. 86567.

Notes on Reinforced Concrete Designing. Gives appendices to the report of the Joint Committee on Reinforced Concrete, explaining the reasons for certain requirements suggested. 2000 w. Eng Rec—Aug. 3, 1907. No. 86091.

Reinforced-Concrete Roofs for Manufactories (Die Eindeckung der Fabrikdächer in Eisenbeton). L. Geusen. A discussion of the value of reinforced concrete as a roofing material with points on roof design. Ills. 3500 w. Serial. 1st part. Beton u Eisen—July, 1907. No. 86270 D.

Reinforced Concrete Structures on the Kansas City Outer Belt & Electric Railroad. Walter W. Colpitts. Illustrates and describes culverts, abutments, bridges, etc. Map. 800 w. Ry Age—Aug. 2, 1907. No. 86121.

A Reinforced Concrete Water Tower at Anaheim. A tower in Southern California is described in detail. Ills. 1500 w. Eng Rec—Aug. 24, 1907. No. 86559.

See also same title under Civil Engineering, Materials of Construction.

Three Light Reinforced-Concrete Arch Bridges at Venice, California. Paul H. Ehlers. Illustrated description of structures across a lagoon near Los Angeles, Cal., stating the conditions and restrictions. 800 w. Eng News—Aug. 29, 1907 No. 86636.

Rock Excavation.

Method of Excavating Rock in Large Masses. George C. McFarlane. Notes

on methods used on the Grand Trunk Pacific Railroad for rocks of extreme hardness. Deep holes and heavy blasts. 2500 w. Eng & Min Jour—Aug. 3, 1907. No. 86103.

Roofs.

A Long-Span Truss Roof: Armory for Squadron C, New York National Guard, New York City. Drawings and description of the general characteristics of the steel riding-hall roof of an armory in Brooklyn. 2500 w. Eng News—Aug. 29, 1907. No. 86631.

Simplon.

The Simplon Tunnel. Francis Fox. A very interesting account of the construction of this great engineering work and matters relating to it. Also discussion and correspondence. Ills. 20500 w. Inst of Civ Engrs —No. 3651. No. 86369 N.

Siphon.

A Reinforced-Concrete Siphon on an Irrigation Canal in Spain. Illustrates and describes the construction of a siphon carrying the main canal across the valleys of the Sosa and the Ribabona, having a total length of about 3,200 ft. 1000 w. Eng News—Aug. 1, 1907. No. 86076.

Timber Trusses.

The Design of Timber Howe Trusses. R. Balfour. Gives a typical design for a ten-panel, 150-ft. span, Howe truss, single-track railway bridge, 25-ft. between lower and upper chords and 16-ft. clear width, explaining the variations from usual practice. 1000 w. Eng News—Aug. 29, 1907. No. 86632.

Tunnels.

The Construction of the Gattico Tunnel of the Santhià-Borgomanero-Arona Railway (Bauausführung des Gattico-Tunnels im Zuge der Santhià-Borgomanero - Arona - Bahn). Gaetano Crugnola. The first part of the serial gives plan and profile of this Italian line and describes the power, shaft, and pumping plants. Ills. 2500 w. Serial. 1st part. Schweiz Bau—July 6, 1907. No. 86254 D.

Warehouse.

The New Warehouse of the Newark Warehouse Company. Illustrates and describes a large 6-story fireproof building in Newark, N. J., combining the facilities of a freight delivery and receiving terminal and a storage warehouse. 4500 w. Eng Rec—Aug. 10, 1907. No. 86315.

MATERIALS OF CONSTRUCTION.

Angles.

Tension Tests of Steel Angles with Various Types of End-Connection. Frank P. McKibben. Read before the Am. Soc. for Test. Mat. Reports tests of 33 steel angles, such as are used for tension members in riveted framed structures. 2500 w. Eng News—Aug. 22, 1907. No. 86510.

Cement.

The Relations between Highly-Basic Blast Furnace Slags and Cement from the Standpoint of Physical Chemistry (Ueber Chemisch-Physicalische Verhältnisse der Hochbasischen Hochofenschlacken und Zemente). Karl Zulkowski. 3300 w. Serial. 1st part. Stahl u Eisen—July 17, 1907. No. 86228 D.

Iron Corrosion.

The Electrolytic Theory of the Corrosion of Iron. Dr. Allerton S. Cushman. Abstract of a paper read at meeting of Am. Soc. for Test. Mat. Reports experimental investigations. Ills. 5500 w. Ir Age—Aug. 8, 1907. No. 86117.

Materials.

On the Study of Material. Editorial on the present day requirements of an intimate knowledge of materials used in engineering work. 2500 w. Eng News —Aug. 29, 1907. No. 86634.

Metal Protection.

Priming Coats for Metal Surfaces: Linseed Oil vs. Paint. F. P. Cheesman. Slightly condensed from a paper read before the Am. Soc. for Test. Mat. Shows that linseed oil by itself is a bad thing. 1500 w. Eng News—Aug. 8, 1907. No. 86308.

Reinforced Concrete.

Investigation of the Thermal Conductivity of Concrete and Embedded Steel and the Effect of Heat Upon Their Strength and Elastic Properties. Ira H. Woolson. Read before the Am. Soc. for Test. Mat. A record of experimental investigations. 2500 w. Eng News—Aug. 15, 1907. No. 86393.

The Slipping Resistance of Steel and Brass in Concrete. H. Burchartz. A report of adhesion tests made with steel and brass rods in concrete. 1200 w. Eng Rec—Aug. 3, 1907. No. 86087.

See also same title under Civil Engineering, Construction.

Tiles.

Ceramic Tiles and Their Use. C. Howard Walker. Gives information regarding the uses of tiles in construction, and designs of methods of obtaining variety in tile work for floors and walls. 2200 w. Br Build—July, 1907. No. 86144 D.

Timber Preservation.

Causes of Decay in Timber. C. W. Berry. Discusses the causes and the use of live steam for treatment in timber preservation. 1500 w. Munic Engng—Aug., 1907. No. 86040 C.

The Preservation of Timber. Gives results, with regard to the penetration of heat into timber during the process of treatment, obtained during investigations carried out for the State Railways of France. 2000 w. Sci Am Sup—Aug. 3, 1907. No. 86068.

We supply copies of these articles. See page 239.

Wood Preservation.

Seasoning of Telephone and Telegraph Poles. Henry Grinnell. From a circular of the U. S. Dept. of Agri. Describes experiments to prolong the service of timbers, particularly those which pertain to the rate of seasoning. 2000 w. Elec Rev, N Y—Aug. 17, 1907. No. 86425.

MEASUREMENT.

Beams.

Test of a Cast Steel Beam. J. V. McAdam. Describes the method of testing devised by the writer. 1500 w. Eng News—Aug. 1, 1907. No. 86077.

Plate Girders.

Distribution of Stresses in Plate-Girders. Cyril Walter Lloyd-Jones. Mathematical study of the relation between stress and strain in a flange-web connection as affecting the distribution of stress in a plate-girder. Appendices. 9000 w. Inst of Civ Engrs—No. 3637. No. 86372 N.

MUNICIPAL.

Gravel Plants.

Gravel Screening and Washing Plants. Brief illustrated descriptions of plants in different localities. 2000 w. Eng News —Aug. 1, 1907. No. 86071.

Pavements.

Cement Filler for Brick Pavements. Requirements and explanations taken from the specifications for laying vitrified brick pavements, approved by the National Brick Manufacturers' Assn. 2500 w. Munic Engng—Aug., 1907. No. 86039 C.

Notes on Tar Macadam. C. F. Wike. Abstracts of remarks offered for discussion at Liverpool, Eng. Does not consider it desirable for steep gradients. Gives specifications, cost, etc. 1000 w. Eng News—Aug. 8, 1907. No. 86311.

Paving Specifications and Inspection. Francis P. Smith. Remarks on the faults of old methods, and the new methods made possible by additional knowledge. 2200 w. Munic Jour & Engr—Aug. 7, 1907. No. 86129 C.

The Asphalt Pavement on the Thames Embankment. Illustrates and describes interesting sheet asphalt work laid on top of the old macadam pavement. 700 w. Eng Rec—Aug. 24, 1907. No. 86558.

River Purification.

River Flushing Plants at Milwaukee, Wis. Describes a system of low-level intercepting sewers, and also flushing plants for purifying fouled rivers. Ills. 2000 w. Eng News—Aug. 1, 1907. No. 86072.

Roads.

The Application of Tar to Macadamized Roads. Thomas Aitken. Extract from a paper read in Scotland. Describes an apparatus for spraying tar, either in a hot or cold state, and its operation, with information in regard to the work. 1500 w. Eng News—Aug. 22, 1907. No. 86513.

Sanitary Code.

The Revised Sanitary Code of the Town of Montclair, N. J. A reprint of this code for a suburb of New York City having a population of about 17,000. Also editorial. 14500 w. Eng News—Aug. 22, 1907. No. 86509.

Sewage.

Chicago's Thirty-ninth Street Sewage Pumping Station. Illustrated detailed description of a station with capacity for handling 1,500,000 gallons a minute. 4500 w. Engr, U S A—Aug. 1, 1907. No. 86130 C.

Sewage Experiments at Matunga, Bombay. Gilbert J. Fowler. Describes work of the sewage experiment station at the Leper Colony, a septic tank installation. The marked septic activity and small sludge residue, under a uniformly high temperature, and the large volume of gas produced are of interest. Ills. 1800 w. Eng News—Aug. 8, 1907. No. 86312.

Sewage Problem of Western Pennsylvania. I. Introductory. Morris Knowles. II. Administration of Pennsylvania Laws Respecting Stream Pollution. F. Herbert Snow. III, Present Condition of Municipal Sewers of Pittsburgh. I. Charles Palmer. Three papers discussed together. 16000 w. Pro Engrs' Soc of W Penn—July, 1907. No. 86396 D.

The Use and the Abuse of Sewage Purification Plants. A. Elliott Kimberly. Condensed from paper read before the Ohio Engng. Soc. Discusses particularly the neglect of such plants in the State of Ohio. 4500 w. Eng News—Aug. 29, 1907. No. 86637.

Work at the Madeleine Sewage Experiment Station, Pasteur Institute of Lille, France. Earle B. Phelps. Information based on two French reports, describing the plant and its operation. 1300 w. Eng News—Aug. 15, 1907. No. 86391.

Sewage Pumping.

New Sewage Pumping Station at Chicago. Athburn W. Meltrose. Illustrated description of the installation of the Thirty-ninth Street pumping station, on the South Side, which will soon be in operation. 3500 w. Power—Aug., 1907. No. 86032 C.

The Efficiency of the Shone System of Pumping. Charles Leslie Cox. Gives data concerning the actual working of this system, with results of tests, carried out on the sewage-pumping plant of the Gosport and Alverstoke Urban District Council. 2200 w. Inst of Civ Engrs—No. 3659. No. 86375 N.

Trade Wastes.

Report on the Disposal of Trade

We supply copies of these articles. See page 239.

Wastes of Reading, Pa. A report of investigations made, giving the conclusions and recommendations. 1200 w. Eng News—Aug. 22, 1907. No. 86512.

WATER SUPPLY.

Boston.

The Metropolitan Water Supply System. Caleb Mills Saville. Illustrated description of reservoirs, aqueducts, and pumping stations belonging to the system that supplies Boston and vicinity. 2000 w. Munic Engng—Aug., 1907. No. 86038 C.

Filtration.

Experiments with a Jewell Filter at the Posen Water Works. E. A. Gieseler. Explains the sources of supply and the remarkable results obtained by mixing in certain proportions the "Herzog" and "Eichwald" water, describing tests made of a Jewell filter. 2500 w. Eng Rec—Aug. 10, 1907. No. 86317.

Irrigation.

A New Egyptian Irrigation Canal. J. B. Van Brussel. Illustrated description of a canal built of riveted steel, and a reinforced concrete service reservoir, forming a part of the scheme for irrigating 125,000 acres in Egypt. 1500 w. Sci Am —Aug. 17, 1907. No. 86418.

Pumping Engines.

See Mechanical Engineering, Hydraulics.

Purification.

New Water Purification Plant at Exeter, N. H. Robert Spurr Weston. Illustrated detailed description of a new plant consisting of a concrete coagulating basin, covered with an arched roof, adjoining two filters and a pipe gallery. Its operation is described. 2300 w. Eng News—Aug. 8, 1907. No. 86309.

Reservoirs.

Stripping Reservoir Sites. A brief summary of report discussing the advisability of stripping the Ashokan reservoir site of New York City's additional supply. Aeration and filtration recommended instead. 2200 w. Munic Jour & Engr—Aug. 7, 1907. No. 86128 C.

Stream Pollution.

The Massachusetts Position Regarding Pollution of Streams by Mill Wastes. Gives the text of the court's statement regarding stream pollution. 2000 w. Eng Rec—Aug. 10, 1907. No. 86316.

Water-Works.

Some Notes on Oriental Water-Works. George A. Johnson. Read before the Am. W.-Wks. Assn. Describes features of Japanese water-works, and of the works at Shanghai, China, Singapore, Straits Settlements, and Bethmangala, and Calcutta, India. 5800 w. Eng Rec—Aug. 24, 1907. No. 86560.

Wood-Stave Pipe.

The Wood-Stave Pipe Line of the Madison River Power Company. W. E. Belcher. Describes this pipe line in western Montana. 800 w. Eng & Min Jour—Aug. 24, 1907. No. 86556.

WATERWAYS AND HARBORS.

Bruges.

The Harbor Works at Bruges and the Port of Call at Zeebrugge, Belgium (Les Installations Maritimes de Bruges et le Port d'Escale de Zeebrugge, Belgique). A. Dumas. An illustrated description of the extensive works, breakwater, docks, canal, etc., recently completed. Plate. 4500 w. Génie Civil—July 20, 1907. No. 86212 D.

Zeebrugge and Bruges. An illustrated account of the construction of new docks in Bruges and a ship canal to Zeebrugge, in the effort to restore the lost trade of this once important city. 3300 w. Engr, Lond—July 26, 1907. No. 86187 A.

Channel Improvement.

New Entrance Channel at Saint Nazaire. Map and description of an important engineering work at the mouth of the Loire River, in France. 2000 w. Engr, Lond—Aug. 9, 1907. No. 86473 A.

The West Neebish Channel of the St. Mary's River. An illustrated account of nearly completed work on this channel which will relieve the present situation and give practically a double course from Lake Superior to Lake Huron. 3500 w. Eng Rec—Aug. 3, 1907. Serial. 1st part. No. 86085.

Coast Protection.

Sea Defence Works at Hornsea. Illustrated description of a concrete sea-wall recently constructed, as part of a scheme of protective works planned. 1200 w. Engr, Lond—Aug. 9, 1907. No. 86475 A.

The de Muralt System of Reinforced Concrete Sea Defenses. An illustrated article describing a system evolved by Mr. de Muralt, applicable to all phases of land protective work. 2500 w. Sci Am Sup—Aug. 3, 1907. No. 86066.

The Form and Energy of Sea-Waves. Gerald Otley Case and Frank J. Gray, in *The Contract Jour.* A discussion of ocean mechanics, and coast erosion. 1500 w. Sci Am Sup—Aug. 3, 1907. No. 86070.

Débris Barrier.

Destruction of Débris Barrier No. 1, Yuba River, California. E. C. Murphy. Illustrates and describes this barrier, constructed to hold back the mining débris, giving an account of its destruction and the probable cause. 1500 w. Eng News —Aug. 8, 1907. No. 86306.

Floods.

Floods and Means of Their Prevention in Our Western Rivers. T. P. Roberts.

We supply copies of these articles. See page 239.

Considers the reservoir and the embankment systems and their limitations. Especially discusses conditions at Pittsburgh. 6000 w. Pro Engrs' Soc of W Penn—July, 1907. No. 86397 D.

Harbor Works.

The Contractor's Plant and Methods on the Harbor Work at Gary, Ind. An illustrated article describing the general arrangement of the harbor, its construction, etc. 3500 w. Eng Rec—Aug. 17, 1907. No. 86420.

Rotterdam.

The Quays at Rotterdam (De Kaaimuurbouw te Rotterdam). H. A. Van Ysselsteyn. Illustrates and describes the various works for the protection of Rotterdam harbor within the last twenty years, with particular reference to some important works now under construction. Ills. 13000 w. De Ingenieur—July 20, 1907. No. 86280 D.

Wave Motion.

Progressive and Stationary Waves in Rivers. Vaughan Cornish. The present number considers progressive waves in rivers caused by added water, such as flood waves, tidal bores, etc. 6800 w. Engng—July 26, 1907. Serial. 1st part. No. 86182 A.

ELECTRICAL ENGINEERING

COMMUNICATION.

Electric Waves.

The Propagation of Electric Waves. A critical statement of the difficulties a student encounters in endeavoring to study the phenomena of wireless telegraphy, especially referring to the detachment of the electric lines of force from the oscillator and their propagation into space. Gives the writer's way of explaining the subject. 4800 w. Elec Rev, Lond—Aug. 2, 1907. No. 86359 A.

Oscillations.

Note on an Oscillographic Study of Low-Frequency Oscillating Arcs. J. T. Morris. Read before the British Assn. Gives observations made on direct and alternating current arcs, chiefly with the object of studying the effect of a change in the medium in which the arc is burning, and also to examine the effect on the arc of a transverse magnetic field. Diagrams. 1500 w. Elec Rev, Lond—Aug. 9, 1907. No. 86459 A.

On the Discharge of Condensers Charged by Transformers, and on the Regulation of Resonance Transformers. A. Blondel. Abstract from *L'Eclairage Electrique*. Considers the working of transformers used for the production of oscillations, and investigates the conditions determining the nature of the secondary discharges. 900 w. Elect'n, Lond—Aug. 2, 1907. No. 86363 A.

The Production of High-Frequency Oscillations from the Electric Arc. L. W. Austin. Abstract from *Bul. of Bureau of Standards*. Gives a short account of the work accomplished in this field, describing the apparatus used by the author in his experimental investigations. 4000 w. Elect'n, Lond—Aug. 2, 1907. No. 86362 A.

Perforator.

Kotyra Keyboard Wheatstone Perforator. Illustrated description of a Wheatstone perforator actuated by a typewriter keyboard which can be applied to existing apparatus. 700 w. Elec Rev, Lond—Aug. 16, 1907. No. 86590 A.

Radiotelegraphy.

Hot-Wire Relay for Selective Signalling. Richard Heilbrun. Describes a retardation relay, the essential part of which is a hot wire. 1000 w. Elec Rev, Lond—Aug. 9, 1907. No. 86460 A.

Note on Tuning in Wireless Telegraphy. Sir Oliver Lodge. Read before the British Assn. Suggestions for sending and receiving at tuned stations, describing a system which eliminates the influence of the earth. 1200 w. Elec Engr, Lond—Aug. 9, 1907. No. 86457 A.

The Arc and Spark in Radiotelegraphy. W. Duddell. Discourse before the British Assn. An explanation and discussion of methods of producing Hertzian waves for wireless telegraphy, and their application and development. 5500 w. Elec Engr, Lond—Aug. 9, 1907. No. 86458 A.

Submarine Cables.

The Pupin Telephone Cable of the Lake of Constance. Editorial on some of the difficulties encountered in submarine telephony, and means of overcoming them, giving an account of the work of laying the Pupin cables in the Lake of Constance. 2000 w. Engng—July 19, 1907. No. 85996 A.

Telegraphy.

Wire-Testing. L. M. Jones. Read before the Assn. of Ry. Tel. Supts. On the work at wire-testing offices, the methods used in locating and clearing of trouble, etc. 2000 w. Elec Rev, N Y—Aug. 24, 1907. No. 86546.

Discussion on "The Rowland Telegraphic System," at New York, April 15, 1907. 6000 w. Pro Am Inst of Elec Engrs—July, 1907. No. 86539 D.

We supply copies of these articles. See page 239.

Telephony.

On the Pupin Mode of Working Trunk Telephone Lines. Sir William Preece. Read before the British Assn. Gives an historical account of the efforts made to overcome the inductive effect, discussing the Pupin method, and giving theoretical reasons for its success. 4800 w. Elect'n, Lond—Aug. 9, 1907. No. 86462 A.

Telephone Troubles (Telephonische Störungen). H. Schreiber and S. Strauss. Discusses several of the accidents peculiar to telephone service with means of prevention. 3200 w. Elektrotechniker—July 10, 1907. No. 86264 D.

The Influence of High-Tension Conductors on Telephone Lines (Ueber den Einflusz der Hochspannungs-Leitungen auf die Betriebs-Fernsprech-Leitungen). F. Schrottke. A mathematical paper giving numerous examples of the effects of both alternating and direct current systems. Ills. 4500 w. Serial. 1st part. Elektrotech Zeitschr—July 18, 1907. No. 86279 D.

The Laying of the Telephone Cable with Self-Induction Coils on the Pupin System in the Bodensee (Ueber das im Bodensee Verlegte Fernsprechkabel mit Selbstinduktionsspulen nach dem Pupinschen System). Dr. Ebeling. Illustrates and describes the cable, its laying and the results obtained. 4000 w. Elektrotech Zeitschr—July 4, 1907. No. 86278 D.

Telephotography.

Telephotography (Fernphotographie). Br. Glatzel. Describes the sending and receiving apparatus of the Korn system, illustrating several examples of transmitted photographs. 2000 w. Verkehrstech Woche u Eisenbahntech Zeitschr—July 20, 1907. No. 86244 D.

Telephotography (La Photographie à Distance). L. Baradel. A review of the development of telegraphic transmission of pictures, illustrating apparatus employed and results obtained. 2500 w. Electricien—July 6, 1907. No. 86202 D.

DISTRIBUTION.

Alternating Current.

Some Notes on Alternating-Current Distribution. A. J. Cridge. Read before the Incor. Munic. Elec. Assn. Shows in the form of curves and concise tables a few of the results obtained recently on the Sheffield (Eng.) system. 3800 w. Mech Engr—July 27, 1907. No. 86158 A.

Current Rectifier.

A Home-Made Alternating-Current Rectifier. Wilmar F. Lent. Explains the essential features involved in the successful action of the electrolytic rectifier, and gives plans for the construction. 2000 w. Sci Am—Aug. 24, 1907. No. 86516.

Mains Records.

Records and Drawings of Electric Mains. W. Mayall Milnes. Describes a scheme drawn up by J. E. Starkie, showing its advantages. Ills. 1500 w. Elec Rev, Lond—Aug. 16, 1907. No. 86591 A.

National Code.

The Influence of the Underwriters' Rules on Electrical Development. C. J. H. Woodbury. Read before the N. Y. Elec. Soc. An account of the work of preparing the National Electrical Code, and showing that it represents a consensus of intelligent opinion. 2800 w. Cent Sta—Aug., 1907. No. 86328.

Rotary Converters.

Hunting in Rotary Converters. Norman G. Meade. Explains the cause and effect of hunting. 1500 w. Elec Wld—Aug. 3, 1907. No. 86151.

Voltage Loss.

Voltage Lost in Direct-Current Wiring. N. A. Carle. Gives charts designed to read directly the volts lost for different strengths of current transmitted over various sizes of wire of different lengths, illustrating their use by examples. 600 w. Power—Aug., 1907. No. 86020 C.

Wiring.

The Fallacies of Free Wiring. G. Basil Barham. A criticism of the system claiming that it does not encourage long hour consumers, and leads to dissatisfaction. 2200 w. Elect'n, Lond—July 26, 1907. No. 86166 A.

DYNAMOS AND MOTORS.

Direct Current.

The Starting, Regulating and Stopping of Continuous-Current Motors. John T. Mould. A discussion of problems and methods giving curves. Ills. 5000 w. Elec Engr, Lond—July 26, 1907. Serial. 1st part. No. 86161 A.

Eddy Currents.

Eddy Current Losses in Alternating-Current Machines with Elliptical Rotating Field (Wirbelstromverluste in Wechselstrommaschinen mit Elliptischem Drehfelde). Reinhold Rüdenberg. A mathematical and theoretical discussion. Ills. 2500 w. Elektrotech u Maschinenbau—July 7, 1907. No. 86250 D.

Electrodes.

Tantalum Electrodes. Günther Schulze. Abstracted from the *Ann. der Physik*. Gives an account of experiments on tantalum electrodes as electrolytic rectifiers. 2000 w. Elect'n, Lond—Aug. 16, 1907. No. 86594 A.

Guarantees.

The Definition and Determination of Guarantees of Efficiency and Drop in Potential in Electrical Machines and Transformers (Definition und Bestimmung der Garantien von Wirkungsgrad und Spannungsabfall bei Maschinen und Transformatoren). Ills. 3500 w. Elektrotech Rundschau—July 17, 1907. No. 86263 D.

We supply copies of these articles. See page 239.

Heating.

Investigations of Heating in Electrical Machines (Untersuchungen zur Frage der Erwärmung Elektrischer Maschinen). Ludwig Ott. Considers heating in the armature and in the field coils, giving formulæ and describing tests to determine the value of coefficients. Ills. 2500 w. Zeitschr d Ver Deutscher Ing—July 20, 1907. No. 86276 D.

Magnet Coils.

Aluminium Coils. Felix Singer. Information concerning a German invention, utilizing the property of aluminium to become covered with a layer of oxide, for winding magnet coils, etc., with bare aluminium wire. 1400 w. Elec Rev, Lond—July 26, 1907. No. 86163 A.

Repulsion Motor.

A Combined Single-Phase and Continuous-Current Series and Compensated Repulsion Motor. E. Danielson. Abstract from *Elektrotechnische Zeitschrift*. Illustrated description. 900 w. Elect'n, Lond—July 26, 1907. No. 86169 A.

Single-Phase.

The Cramp Single-Phase Motor. W. Cramp. A report of tests of this machine. 2000 w. Elec Rev, Lond—Aug. 9, 1907. No. 86461 A.

Synchronous Motors.

Circular Current Loci of the Synchronous Motor. A. S. McAlister. Describes certain simple circular current loci of the synchronous motor which allow its characteristics to be determined equally as readily as does the circular current locus of the induction motor. 3500 w. Elec Wld—Aug. 24, 1907. No. 86544.

The Use of the Synchronous Motor as Phase Compensator. R. E. Hellmund. A study of the relation of capacity of synchronous motors to percentage fuel-load power-factor, discussing a series of cases covering the conditions which occur most frequently in practice. 2000 w. Elec Rev, N Y—Aug. 24, 1907. No. 86545.

ELECTRO-CHEMISTRY.

Copper Corrosion.

Corrosion of Copper and Copper-Alloys. John G. A. Rhodin. Remarks on the close connection between chemical and electrical phenomena, introducing a theory of dissolution of metals, considering the problem more as an electrical one than a chemical. 4000 w. Engr, Lond—July 19, 1907. Serial. 1st part. No. 85998 A.

Electric Smelting.

See Mining and Metallurgy, Iron and Steel.

Hydrates.

Hydrates in Solution. Abstracts of four papers contributed to the general discussion of this subject at a meeting of the Faraday Society. I. Thermochemistry of Electrolytes. W. R. Bousfield and T. M. Lorry. II. Hydrates in Solution. Dr. J. C. Philip. III. Methods for Determining the Degree of Hydration. Dr. G. Senter. IV. Stability of Hydrates. Dr. A. Findlay. 8500 w. Elect'n, Lond—July 26, 1907. No. 86168 A.

ELECTRO-PHYSICS.

Ether.

On the Motions of Ether Produced by Collisions of Atoms or Molecules Containing or Not Containing Electrodes. Lord Kelvin. Read before the British Assn. A study of the motions of ether. 3000 w. Elect'n, Lond—Aug. 16, 1907. No. 86592 A.

Ionization.

The Nature of Ionization—Ionomania. H. E. Armstrong. Read before the British Assn. The author considers the word "ionization" is being improperly used, "dissociation" being really all that is usually implied. 2500 w. Elect'n, Lond—Aug. 9, 1907. No. 86464 A.

Resistance.

The Variation of Manganin Resistances with Atmospheric Humidity. W. Jaeger and St. Lindeck. A criticism of statements made by Messrs. Rosa and Babcock in an earlier paper. 1200 w. Elect'n, Lond—Aug. 2, 1907. No. 86360 A.

Thermo-Couples.

The Thermoelectromotive Forces of Potassium and Sodium with Platinum and Mercury. Harold C. Barker. Deals with the measurement of the thermoelectromotive forces of potassium-platinum and sodium-platinum couples for varying temperatures. 2000 w. Am Jour of Sci—Aug., 1907. No. 86023 D.

GENERATING STATIONS.

Accumulators.

The Present Status of the Iron-Nickel Accumulator (Etat Actuel de l'Accumulateur Fer-Nickel). M. Jumau. Gives the theory and construction of the Edison cell, a report of elaborate tests and a discussion of the results. Also remarks by M. Janet. Ills. 15000 w. Bull d l Soc Inter d Elect'ns—July, 1907. No. 86223 F.

Central Station.

A Progressive Suburban Central Station at Revere, Mass. Illustrates and describes a power plant developed under unusual load requirements, in a suburban territory. 2200 w. Elec Wld—Aug. 3, 1907. No. 86146.

Electric Power Plant at Lansford, Pennsylvania. W. E. Joyce. Illustrated description of a new plant costing $1,000,000, built to supply 16 coal mines with power, and for other uses. 2000 w. Eng & Min Jour—Aug. 24, 1907. No. 86554.

Economics.

The Financial Side of the Central Sta-

tion. A. D. Williams, Jr. Outlines some of the elements affecting the fixed charges and operating expenses, computing approximately what the fixed charges would be upon an investment. 2500 w. Elec Wld—Aug. 3, 1907. No. 86148.

Geneva, Switzerland.

The Reserve and Emergency Station of the City of Geneva (Usine de Réserve et de Secours de la Ville de Genève). M. Elmer. Illustrates and describes a secondary steam installation at the Chèvres hydro-electric station, made necessary by the large fluctuations in the River Rhone. 2000 w. Bull Tech d l Suisse Rom—July 10, 1907. No. 86204 D.

Hydro-Electric.

Power Plant Inside of a Dam on the Patapsco River. Illustrated description of a recently completed plant near Ilchester, Md., which is entirely submerged, the same structure serving as dam and power house. 1500 w. Elec Wld—Aug. 3, 1907. No. 86145.

The Caffaro Electric Power Station. Illustrates and describes the utilization of this Alpine stream to develop power for Brescia and neighboring districts. 1200 w. Engng—Aug. 9, 1907. No. 86468 A.

The Hydro-Electric Plant at Trezzo on the Adda (L'Impianto Idro-Elettrico di Trezzo sull' Adda). An illustrated detailed description of this plant, the first part discussing the dam and other hydraulic works. 2700 w. Serial. 1st part. Il Monit Tec—July 20, 1907. No. 86218 D.

The Kern River No. 1 Power Plant of the Edison Electric Co., Los Angeles. C. W. Whitney. An illustrated detailed description of interesting features of this high-head long-distance transmission plant. 6500 w. Eng Rec—Aug. 10, 1907. Serial. 1st part. No. 86314.

Lagging Currents.

Synchronous Motor Compensation for Lagging Currents. Clarence P. Fowler. Discusses the effects of lagging wattless currents on power station equipment and on the supply circuits. 4000 w. Elec Wld—Aug. 10, 1907. No. 86338.

Power-Factor.

Synchronous Motors for Improving Power-Factor. William Nesbit. Discusses the most efficient point to which the power-factor should be raised, and the advantage derived by installing a synchronous motor in a specific case. Short editorial. 3000 w. Elec Jour—Aug., 1907. No. 86309.

Rates.

Electric Power Tariffs. C. S. Vesey-Brown. Considers the charges made by hydro-electric and steam generating plants, analyzing the different tariffs in operation. 2000 w. Cassier's Mag—Aug., 1907. No. 86007 B.

Storage Batteries.

Improvements in Edison's Secondary Battery. Illustrated description of two inventions by Thomas A. Edison, upon which patents have been recently granted, to improve the operation and increase the efficiency of storage batteries. 1500 w. Sci Am Sup—Aug. 24, 1907. No. 86520.

Turbine Station.

The New Power Station of the South Metropolitan Electric Light and Power Co. Briefly considers power supply in London, and gives an illustrated description of the modern turbine station recently erected at East Greenwich. 2200 w. Elec Rev, Lond—Aug. 2, 1907. No. 86358 A.

The Central Station of the Société du Gaz et de l'Electricité, of Nice, France. C. L. Durand. Illustrated description of a steam turbine plant of considerable size. 2500 w. Elec Rev, N Y—Aug. 10, 1907. No. 86327.

LIGHTING.

Filaments.

Experiments on Osram, Wolfram, Zircon, and Other Lamps. J. T. Morris, F. Stroude, and R. Milward Ellis. Gives results of researches on the physical properties of such lamps, discussing the effect of voltage variation when the lamp is working on direct-current. 1700 w. Elect'n, Lond—July 26, 1907. Serial. 1st part. No. 86165 A.

Incandescent Lamps.

Government Incandescent Lamp Specifications. Gives the main portions of specifications as contained in a recent call for proposals for lamps to be supplied for U. S. Government service. 2000 w. Elec Wld—Aug. 3, 1907. No. 86147.

Developments in Electric Incandescent Lamps. Leon Gaster. A short review of some of the most important improvements in metallic filaments and vacuum tubes. 4500 w. Elec Engrs, Lond—Aug. 16, 1907. No. 86589 A.

Recent Progress in Electric Incandescent Lamps. Lionel Calisch. Briefly reviews recent improvements made to increase the efficiency, concluding that the light of the future will probably be either a luminescent gas or vapor. 1500 w. Cassier's Mag—Aug., 1907. No. 86011 B.

New Illuminants.

New Lights and New Illuminants from the Central Station's Point of View. R. S. Hale. Read before the Ill. Engng. Soc. Suggestions for the handling of the new lamps and points from the writer's experience. 3500 w. Elec Rev, N Y—Aug. 17, 1907. No. 86424.

Resistance.

The Beck "Regler." Illustrates and describes this automatic resistance for maintaining constant current for arc

We supply copies of these articles. See page 239.

lamps, electric furnaces, etc. 350 w. Elec Engr, Lond—Aug. 2, 1907. No. 86357 A.

Terminology.

The Concepts and Terminology of Illuminating Engineering. Dr. Clayton H. Sharp. Presidential address delivered at the convention of the Ill. Engng. Soc., Boston. Aims to show the utility of certain ideas and names, outlining the line of development recommended. 4000 w. Elec Rev, N Y—Aug. 10, 1907. No. 86326.

Vacuum Tubes.

The Occlusion of Residual Gas by the Glass Walls of Vacuum Tubes. A. A. Campbell Swinton. Abstract of a paper read before the Royal Soc. describing investigations on this subject. 1400 w. Elect'n, Lond—July 26, 1907. No. 86170 A.

Voltage.

The Case for Low Pressure. A. C. Hanson. Discusses the relative suitability of high and low voltage for different types of lamps and for motors. 2500 w. Elec Rev, Lond—July 26, 1907. No. 86164 A.

MEASUREMENT.

Instrument Transformers.

Instrument Transformers. Charles C. Garrard. Considers the measurement of high potentials, insulation of instrument transformers, terminals of current, testing polarity, etc. Ills. 2500 w. Elec Engr, Lond—July 26, 1907. Serial. 1st part. No. 86160 A.

Meters.

Shunted Type of Graphic Recording Meters. Paul MacGahan and H. W. Young. An illustrated description of the construction, stating its advantages. 1800 w. St Ry Jour—Aug. 24, 1907. No. 86543.

Protometers.

A New Comparison Photometer. Dr. Charles H. Williams. Read before the Ill. Engng. Soc. Describes a portable instrument for measuring the light reflected from surfaces to determine whether one method of lighting is better than another. 1000 w. Am Gas Lgt Jour—Aug. 19, 1907. No. 86435.

Illumination Photometers and Their Use. Preston S. Millar. Read before the Ill. Engng. Soc. General discussion of the aim of illumination photometers, giving illustrated descriptions of eleven types. 7000 w. Am Gas Lgt Jour—Aug. 19, 1907. No. 86436.

Standards.

Report of the British Association Committee on Practical Standards for Electrical Measurements. 4500 w. Elect'n, Lond—Aug. 16, 1907. No. 86593 A.

Synchroscope.

The Synchroscope. S. R. Dodds. Diagram and description of its operation. 1000 w. Elec Wld—Aug. 17, 1907. No. 86432.

TRANSMISSION.

Direct-Current.

Critical Consideration of the High-Tension Direct-Current System of Electric Power Transmission. Abstract of an article in *Elektrotechnic und Maschinenbau*, discussing critically Mr. Highfield's recent paper. 1200 w. Elect'n, Lond—July 26, 1907. No. 86167 A.

Insulators.

Three New Electrical Devices. Illustrates and describes two new insulating devices, and a horizontal support for conductors, recently patented by Louis Steinberger. 1500 w. Sci Am Sup—Aug. 10, 1907. No. 86305.

Lightning Arrester.

The Electrolytic Lightning Arrester. R. P. Jackson. Illustrates and describes the electrolytic or aluminum-cell arrester. 700 w. Elec Jour—Aug., 1907. No. 86401.

Phasing.

Problem in Phasing. J. P. Jollyman. An illustration of a simple method of solving phasing problems. 400 w. Elec Wld—Aug. 3, 1907. No. 86150.

Poles.

Experiments with Concrete Telegraph Poles. G. A. Cellar. Read before the Assn. of Ry. Tel. Supts. Also tests by Robert A. Cummings. Ills. 5500 w. Cement Age—Aug., 1907. No. 86483.

Switch-Gear.

Mechanical Considerations in the Design of High-Tension Switch-Gear. Henry William Edward Le Fanu. Illustrates and describes examples of high-tension switch-gear, which have successfully borne the test of practice. Discussion and correspondence. 20500 w. Inst of Civ Engrs —No. 3589. No. 86368 N.

Wire Outlets.

A Suggestion for a High-Tension Wire Entrance. H. C. Reagan. Illustrates and describes the outlets adopted for the Pittsburg & Butler Street Ry. Co. which give air insulation. 700 w. Elec Ry Rev —Aug. 17, 1907. No. 86441.

MISCELLANY.

Accidents.

Accidents with Electrical Machinery. Information from the last annual report of G. S. Ram, Inspector of Factories in England. 4000 w. Mech Engr—July 27, 1907. No. 86159 A.

Cells.

Selenium Cells. R. A. L. Snyder. Read before Pittsburg Sec. of Inst. of Elec. Engrs. Information concerning selenium and the uses to which it has been applied. Short discussion. Ills. 4000 w. Pro Am Inst of Elec Engrs—July, 1907. No. 86530 D.

We supply copies of these articles. See page 239.

Standard Cells. K. E. Guthe and C. L. von Ende. From the *Physical Rev.* Gives results of experiments on both Clark and Cadmium cells, having regard to the materials used in construction. 2000 w. Elect'n, Lond—Aug. 16, 1907. No. 86595 A.

Dumb-Waiters.

Electric Dumb-Waiter Machines and Systems. E. L. Dunn. Describes briefly the principal features of modern dumb-waiters, referring to the system installed in the new Plaza Hotel, New York City. Ills. 1600 w. Elec Wld—Aug. 3, 1907. No. 86149.

Education.

On the Concentric Method of Teaching Electrical Engineering. V. Karapetoff. Outlines the concentric method of education, discussing also the present method. 5000 w. Pro Am Inst of Elec Engrs—July, 1907. No. 86536 D.

The Attitude of the Technical School Toward the Profession of Electrical Engineering. Henry H. Norris. Examines the methods of instruction in technical schools in order to ascertain how the requirements are being met, and to note the progress made. 3500 w. Pro Am Inst of Elec Engrs—July, 1907. No. 86534 D.

Standardization.

Standardization Rules of the American Institute of Electrical Engineers. Gives rules approved and accepted June, 1907. 12000 w. Pro Am Inst of Elec Engrs—July, 1907. No. 86535 D.

INDUSTRIAL ECONOMY

Agreements.

Working Agreements Between Manufacturers. J. F. Gairns. Reviews briefly some of the more important aspects of the subject of working agreements between firms actually independent but co-operating for mutual benefit. 2000 w. Cassier's Mag—Aug., 1907. No. 86010 B.

American Trade.

American Trade Opportunities and Handicaps in South America. Lewis R. Freeman. Discusses the obstacles that work to the disadvantage of American trade. 4500 w. Engineering Magazine—Sept., 1907. No. 86606 B.

Apprenticeship.

The Training of Apprentices in Foundry Work. Brief account of a successful course of education introduced by the Ingersoll-Rand Co., at their Phillipsburg, N. J., shops. 2000 w. Foundry—Aug., 1907. No. 86014.

Cost Keeping.

An Economical and Practical Cost System. B. A. Franklin. Describes a simple and effective shop cost system for machine builders, the forms used, and its installation in a factory. 3800 w. Am Mach—Vol. 30, No. 32. No. 86197.

Costs.

What Constitutes Cost of Production. F. E. Webner. The eleventh of a series of articles on cost-keeping. Also supplement. 2000 w. Ir Trd Rev—Aug. 1, 1907. No. 86034.

Depreciation.

Depreciation. P. D. Leake. A plea for the study and use of better methods of measuring and providing for depreciation of industrial plants. 4500 w. Mech Engr—July 27, 1907. Serial. 1st part. No. 86157 A.

Dock Business.

Dock Capital, Expenditure, Receipts, and Management. Lee Galloway. Detailed discussion of the business of a dock system. 5400 w. Jour of Acc—Aug., 1907. No. 86521 C.

Education.

Address to the Engineering Section of the British Association at Leicester. Silvanus P. Thompson. Deals with the interaction of science and engineering, education and training of engineers, etc. 9000 w. Engng—Aug. 2, 1907. No. 86365 A.

Shop Work at an Engineering School. W. S. Graffam. Discusses the aim of shop practice in such a school, the needs, etc. 2000 w. Mach, N Y—Aug., 1907. No. 86136 C.

The Foundry Plant of the Siegen School for Iron and Steel Technology (Die Giesserei-Anlagen der Königlichen Fachschule für die Eisen- und Stahlindustrie des Siegener Landes zu Siegen). An illustrated description of the method and equipment for teaching foundry work at this German trade school. 2000 w. Stahl u Eisen—July 3, 1907. No. 86226 D.

The Training in Foundry Work at Pratt Institute. William C. Stimson. An illustrated description of the course of instruction given. 7000 w. Foundry—Aug., 1907. No. 86022.

The Training of Economic Geologists and the Teaching of Economic Geology. John A. Reid. Gives the writer's views of the preparation required and the methods of teaching. 3500 w. Ec Geol—June, 1907. No. 86488 D.

Eight-Hour Day.

The Reduction of the Working Day to Eight Hours (La Réduction de la Journée de Travail à Huit Heures). Maurice

We supply copies of these articles. See page 239.

Alfassa. An exhaustive consideration of its economic effects in French government works, the first number of the serial dealing with the postal and naval departments. 7000 w. Serial. 1st part. Bull d l Soc d'Encour—July, 1907. No. 86205 F.

Government Ownership.

See Railway Engineering, Miscellany.

Industrial Betterment.

Industry and Social Politics (Industrie und Sozialpolitik). R. Krause. A discussion of schemes for industrial betterment now occupying the attention of the German Reichstag. 2500 w. Stahl u Eisen—July 3, 1907. No. 86227 D.

Labor Agreement.

Labor Agreement in the Engineering Trades. Editorial reviewing the terms of agreement settled on March 22, 1907, which are soon to be ratified or condemned by the votes of the whole body of members of the unions. 1900 w. Engng—July 26, 1907. No. 86180 A.

Library System.

The Library System of Stone & Webster. G. W. Lee. A paper describing the library system of a firm having general control of some thirty public service corporations in various parts of the country. The library is at the service of them all, though particularly for the headquarters in Boston. 4500 w. Eng Rec—Aug. 24, 1907. No. 86561.

Lowest Tender.

Ethics of the Lowest Tender. Ian Gorach. Discusses some of the ethical considerations relating to tenders. 1600 w. Elec Rev, Lond—July 26, 1907. No. 86162 A.

Municipal Ownership.

General Conclusions of the Municipal Ownership Committee of the National Civic Federation. A summary of the conclusions reached by the National Civic Federation, with editorial comment. 4000 w. Eng News—Aug. 15, 1907. No. 86390.

Municipal Plants.

Municipal Electric Lighting. Ernest S. Bradford. A review of conditions and statistics in the United States. 3000 w. Munic Jour & Engr—Aug. 21, 1907. No. 86498 C.

Power Plants.

The Central Station and the Isolated Plant. H. S. Knowlton. Discusses the considerations governing the selection of each class of service for industrial purposes. 2800 w. Cassier's Mag — Aug., 1907. No. 86013 B.

Premium System.

Fixing Premium Rates Discussed. Forrest R. Cardullo. Condemns old methods and suggests a new one based on minimum total cost and no limit to possible earnings. 2500 w. Am Mach—Vol. 30, No. 31. No. 86055.

Railway Valuation.

See Improvements, under Railway Engineering, Permanent Way.

Shop Management.

See Management, under Mechanical Engineering, Machine Works and Foundries.

Socialism.

Concerning Wealth and Wage Earners. Editorial making a comparison between the earnings of capital and the earnings of labor, and giving much information of interest. 3000 w. Eng News—Aug. 1, 1907. No. 86079.

Wages.

The Wages Problem (Le Problème des Salaires). Dr. Franz Oppenheimer. A discussion of the economic problems connected with the fixing of wages. 6000 w. Rev Econ Inter—July, 1907. No. 86281 H.

MARINE AND NAVAL ENGINEERING

Battleships.

Ventilation and Refrigeration of Ammunition-Holds. Adrien Bochet. Abstract trans. of a paper read at the Bordeaux Int. Cong. Discusses methods of insulating holds, and ventilation by cooled air. 2200 w. Engng—July 26, 1907. No. 86185 A.

Cruiser.

The New United States Scout Cruiser "Salem." Illustrates and describes what is said to be the fastest ship in the U. S. Navy. 900 w. Sci Am — Aug. 17, 1907. No. 86416.

Dreadnought.

The "Dreadnought" ("Dreadnought"). Ernst Müller. A detailed description from both technical and naval points of view. 2500 w. Serial. 1st part. Schiffbau —July 10, 1907. No. 86246 D.

Dry-Dock.

Opening of the Large Dry-Dock at League Island. Illustration, with brief description of this dry-dock near Philadelphia. 500 w. Sci Am—Aug. 24, 1907. No. 86515.

Floating Dock for Trinidad. Gives 2-page plate and other illustrations, with description of this self-docking floating dock. 700 w. Engng—July 26, 1907. No. 86178 A.

Present and Prospective Docking Facilities of the Pacific Coast. H. A. Crafts. Brief account of present facilities, and of

We supply copies of these articles. See page 239.

the large drydock soon to be constructed at Hunter's Point. 1200 w. Sci Am—Aug. 3, 1907. No. 86060.

Electricity.

Electricity on Board Ship. Sydney F. Walker. First of a series of articles describing apparatus used, explaining the principles of the construction, and arrangement of cables, different forms of wireless telegraphic apparatus, etc. 4500 w. Marine Rev—Aug. 1, 1907. Serial. 1st part. No. 86123.

Exhibition.

The International Naval Exhibition at Bordeaux, 1907 (Die Internationale Schiffahrtausstellung in Bordeaux, 1907). W. Kaemmerer. The first part describes the grounds and buildings and commences a description of the exhibits. Ills. 2000 w. Serial. 1st part. Zeitschr d Ver Deutscher Ing—July 13, 1907. No. 86272 D.

Feed Water.

Sea Water and the Use of the Salinometer. Jas. Shirra. Abstract of a paper read before the Inst. of Marine Engrs. Explains the difference between "density" and "salinity," and the objections to the use of sea water for feeding marine boilers. 2000 w. Mech Engr—Aug. 17, 1907. No. 86588 A.

Fulton.

Fulton in France. Henry Harrison Suplee. An interesting illustrated account of Fulton's life in France, from 1797 to 1806, and his experiments with submarines and steamboats. 5500 w. Cassier's Mag—Sept., 1907. No. 86614 B.

Hydroplanes.

A Practical Gliding Craft with Submerged Hydroplanes. Illustrations, with description of a new gliding craft invented by Peter Cooper Hewitt. 2500 w. Sci Am—Aug. 3, 1907. No. 86061.

Indicator Cards.

Combined Indicator Cards. Charles S. Linch. Gives cards from every-day running of the City of Chester, and the Mohican, with particulars of the vessels. 1600 w. Int Marine Engng—Sept., 1907. Serial. 1st part. No. 86574 C.

Internal-Combustion Engines.

Internal-Combustion Engines for Marine Purposes. James Tayler Milton. States the conditions to be satisfied by a successful marine engine, discussing the application of internal-combustion engines, especially dealing with variable speed and balancing. Discussion and correspondence. 20800 w. Inst of Civ Engrs, No. 3678. No. 86370 N.

Kronprinzessin Cecilie.

Kronprinzessin Cecilie. Brief illustrated description of this fine twin-screw express steamship of the North German Lloyd Steamship Co. 2500 w. Marine Rev—Aug. 22, 1907. No. 86540.

Light-Draft.

Light-Draft Single Screw Passenger Steamer. Illustrates and describes the steel steamer Kalika, intended for service in and around Bombay, India. 4000 w. Int Marine Engng—Sept., 1907. No. 86576 C.

Light Vessels.

Single Screw Steam Light Vessels. Drawings and description of vessels for the United States Government, built according to the standard specification adopted. Engng—Sept., 1907. Serial, 1st part. No. 86579 C.

Liner.

The New Indian Liner City of London. Illustrated detailed description of the vessel and its equipment. 1200 w. Int Marine Engng—Sept., 1907. No. 86573 C.

"Lusitania."

The Cunard Turbine-Driven Quadruple-Screw Atlantic Liner "Lusitania." A brief review of the progress of marine construction as applied to Atlantic steamships, with full illustrated detailed description of this vessel, and much information relating to its construction and equipment. Also editorial. 35000 w. 9 plates. Engng—Aug. 2, 1907. No. 86364 A.

The Saloons of the "Lusitania." Gives an 8-page supplement of engravings, with description of the artistic furnishings and decorations. 3000 w. Engng—July 19, 1907. No. 85992 A.

The 25-Knot Turbine Liner "Lusitania." Illustrations with brief description of this new liner. 1200 w. Sci Am—Aug. 10, 1907. No. 86301.

Merchant Ships.

Structural Development in British Merchant Ships. J. Foster-King. Read before the Inst. of Nav. Archts. A review of the development, referring especially to the Great Eastern, and to the Mauretania and Lusitania, and other types, and discussing features of design. Ills. 4800 w. Engng—July 19, 1907. No. 85997 A.

Motor Boats.

The "Typhonoid"—A New Type of Motor Boat. M. J. Peltier. Illustrates and describes a new racing boat recently launched at a French shipyard. The invention of M. André Gambin. 500 w. Sci Am—Aug. 24, 1907. No. 86517.

Pallograph.

The Electric Pallograph. Illustrated description of an instrument, designed by Otto Schlick, for measuring and registering the vibrations of steamships. 1300 w. Prac Engr—Aug. 16, 1907. No. 86584 A.

Propulsion.

The Propulsion of Ships by Means of Non-reversible Engines. Drawings and description, from *Rivista Marittima*, of vessels employing non-reversible engines, using four direct propulsion electric mo-

We supply copies of these articles. See page 229.

tors actuated by current from generators operated by the engines. 2300 w. Int Marine Engng—Sept., 1907. No. 86578 C.

Revenue Cutter.

Revenue Cutter Pamlico. Illustrates a vessel for the North Carolina sounds, recently put in service. Also gives a brief account of the U. S. revenue cutter service. 3500 w. Naut Gaz—Aug. 22, 1907. No. 86564.

Schooner.

The Auxiliary Coasting Schooner Northland. Describes the vessel, said to be the largest motor schooner in the world, and the gasoline engines. 1500 w. Int Marine Engng—Sept., 1907. No. 86575 C.

Sectional Construction.

Sectional Work in Ship Construction. J. L. Twaddell. Remarks on the changed conditions in industrial engineering which have caused the subdivision of work and the greater use of machinery. General discussion. 3500 w. Trans N-E Coast Inst of Engrs & Shipbldrs—July, 1907. No. 86491 N.

Shipyards.

The Werf Gusto of A. F. Smulders in Holland. Frank C. Perkins. Illustrated description of this shipbuilding yard. 1500 w. Int Marine Engng—Sept., 1907. No. 86577 C.

Steam Navigation.

Robert Fulton and the Centenary of Steam Navigation. A brief account of the events that led to the development and circumstances connected with it. Ills. 2200 w. Engr, Lond—Aug. 16, 1907. No. 86602 A.

Submarines.

The Present and Future of Submarine Navigation. A. M. Laubeuf. Abstract translation of a paper read at Bordeaux Int. Cong. of Naval Archt. Discusses the field of activity for submarines, the differences between the submarine and submersible types, and related subjects. 3500 w. Engng—July 26, 1907. No. 86183 A.

Trim Curves.

Trim Curves. A. E. Long. Shows how curves of sectional areas at different trims can be obtained, and how their properties can be utilized for trim calculations. Also discussion. 2 plates. 6000 w. Trans N-E Coast Inst of Engrs & Shipbldrs—July, 1907. No. 86490 N.

Turbiners.

New American Turbine Steamers Yale and Harvard. Illustrated description of these boats, with sketch of the company which owns them. 6500 w. Naut Gaz—Aug. 8, 1907. No. 86318.

Resumed Discussion on the Hon. C. A. Parsons and Mr. R. J. Walker's Paper on "Marine Steam Turbine Development." 8700 w. Trans N-E Coast Inst of Engrs & Shipbldrs—July, 1907. No. 86489 N.

Vibration.

See also Pallograph.

Wrecking Steamer.

A New American Wrecking Steamer Relief. Illustrated description of a vessel built for service in the West Indies. 1000 w. Naut Gaz—June 27, 1907. No. 85338.

Yacht.

The Steam-Yacht Medusa. Illustrations, with brief description. 500 w. Engng—July 26, 1907. No. 86179 A.

MECHANICAL ENGINEERING

AUTOMOBILES.

Commercial Vehicles.

The Fawcett-Fowler Steam-Car. Illustrated description of an interesting heavy steam-motor vehicle. 1500 w. Engng—July 19, 1907. No. 85995 A.

Competition.

The Competition for the Kaiser's Prize (Das Kaiserpreisrennen). M. Ettlinger. Gives tables showing the characteristics of the competing cars and their performances during the test. Ills. 8000 w. Zeitschr d Mit Motorwagen Ver—July 31, 1907. No. 86259 D.

Results of the American Automobile Association's Fourth Annual Tour for the Glidden and Hower Trophies. Brief account of results with illustrations of successful cars. 1500 w. Sci Am—Aug. 3, 1907. No. 86062.

The *Grand Prix* of the Automobile Club of France in 1907 (Le Grand Prix de l'Automobile-Club de France en 1907). Ch. Dantin. Gives details of the cars taking part in this race on the "Dieppe circuit" and illustrates and describes the winners. 3500 w. Génie Civil—July 13, 1907. No. 86211 D.

Construction.

Reliability in Car Construction. F. Strickland. Gives some interesting statistics and deductions from results of the Scottish Reliability Trials. 2000 w. Autocar—Aug. 17, 1907. No. 86582 A.

Daimler-Mercedes.

The Daimler-Mercedes Petrol Cars. Illustrated detailed description of leading features of these chain-driven cars. 1500 w. Auto Jour — Aug. 10, 1907. No. 86449 A.

We supply copies of these articles. See page 239.

Dinin.

The Dinin Electric Automobiles (Les Automobiles Electriques "Dinin"). J. A. Montpellier. Illustrated description of the car, motor, storage batteries, etc. 2500 w. Electricien—July 13, 1907. No. 86203 D.

Dust.

The R. A. C. Dust Trials. Illustrations of some of the special devices entered, and of cars being driven over the prepared surfaces. 400 w. Auto Jour—Aug. 3, 1907. No. 86346 A.

Exposition.

The Display of Motor Cycles and Automobiles at Milan, 1907 (La Mostra del Ciclo e dell' Automobile, Milano, 1907). Begins an illustrated description of the various exhibits at this show. 1800 w. Serial. 1st part. Industria—July 14, 1907. No. 86221 D.

Franklin.

More Horse-Power for Franklins in 1908. An illustrated article describing the improvements introduced in the new models of this car. 2000 w. Automobile—Aug. 22, 1907. No. 86523.

Fuels.

Possible Fuels for Motor Cars. Condensed report of the Motor Union Fuels Committee. 3000 w. Auto Jour—July 27, 1907. No. 86155 A.

Knocking.

Knocking in Motors: Its Cause and Effect. An explanation of the causes and effects. 2000 w. Automobile — Aug. 22, 1907. No. 86522.

Mors.

The Mors Petrol Cars. The present article illustrates and describes the frame and suspension, and the engine. 1500 w. Auto Jour—Aug. 17, 1907. Serial. 1st part. No. 86581 A.

Omnibuses.

Gasoline Buses for New York. Brief illustrated description of vehicles recently placed in service on Fifth Avenue. 1200 w. St Ry Jour—Aug. 24, 1907. No. 86542.

The Motor 'Bus in London. Extracts from the proceedings of meetings held in London to discuss the use of heavy motor vehicles on London streets. 3500 w. Auto Jour—Aug. 3, 1907. No. 86348 A.

Reliability Trials.

Scottish Reliability Trials—Report and Results. An illustrated report of the Scottish Auto-Club, with tabulated results. 5000 w. Auto Jour—Aug. 3, 1907. No. 86347 A.

Skidding.

How Far Skidding is Due to Road Surfaces. Douglas MacKenzie. Read before the Roy. Auto. Club of Gt. B. & Ire. Discusses briefly the materials and construction of non-skidding roads. 1200 w. Automobile—Aug. 15, 1907. No. 86440.

Starting.

Motor Starting Devices for Gasoline Automobiles. Harold H. Brown. Illustrates and describes some ingenious mechanical contrivances that do away with the starting crank. 3000 w. Sci Am Sup—Aug. 3, 1907. No. 86067.

Wheels.

The Rudge-Whitworth Detachable Wire Wheel. Illustrations of the wheel, with remarks on its advantages. 1200 w. Auto Jour—Aug. 17, 1907. No. 86580 A.

COMBUSTION MOTORS.

Design.

Producer Gas Engine. F. W. Burger. Calls attention to points to be considered in designing this type of engine. 2000 w. Engr, U S A—Aug. 1, 1907. No. 86134 C.

Diesel Motors.

The Design of a Two-Cycle, Reversible Diesel Motor (Metodo di Calcolo di un Motore "Diesel" a due Tempi, Reversibile). Alessandro Guidoni. A concrete example, fully worked out, of the method of designing Diesel motors for marine service. Ills. 6000 w. Rivista Marittima—July-Aug., 1907. No. 86215 E + F.

Exhaust Gases.

On the Gases Exhausted from a Petrol Motor. Prof. B. Hopkinson and L. G. F. Morse. Read before the British Assn. Describes investigations dealing with the conditions under which carbon monoxide is formed in a high-speed internal-combustion motor, and the relation between the composition of the exhaust gases, the strength of the mixture, the power developed, and the thermal efficiency. 2500 w. Engng—Aug. 9, 1907. No. 86472 A.

Gas Engines.

See also Marine and Naval Engineering.

The Present Position of Gas and Petrol Engines. Dugald Clerk. Read before the British Assn. Considers the difficulties in constructing large gas engines, describes experiments with the object of compounding gas engines and concludes with a few general remarks on petrol engines. 4000 w. Elect'n, Lond—Aug. 9, 1907. No. 86463 A.

Gas Producers.

A New Type of Pressure Producer. Illustrated description of type F Westinghouse producer, with no gas holder, the gas supply being regulated by throttling the steam blast. 1200 w. Engr, U S A—Aug. 15, 1907. No. 86413 C.

Gas Testing.

A Commercial Method of Testing Producer Gas for Sulphur. Randolph Bolling. Outlines briefly Bunte's method, and Drehschmidt's method, and gives a description of the writer's method. 900 w. Eng News—Aug. 1, 1907. No. 86073.

We supply copies of these articles. See page 239.

Ignition.

Bradley's Ignition Device. Illustrates and describes an ignition device for internal-combustion engines, aiming to secure efficient work at high speeds, and capable of giving but a single spark. 1000 w. Mech Engr—Aug. 19, 1907. No. 86454 A.

Eisemann H. T. Magneto Ignition Systems. An illustrated description of the wiring system of this device. 1800 w. Autocar—Aug. 10, 1907. No. 86450 A.

Oil Engines.

Oil Engine for Marine Purposes. F. M. Timpson. Read before the Inst. of Marine Engrs. Describes oil engines, and gives information in regard to applications, especially for marine purposes. 3000 w. Marine Rev—Aug. 1, 1907. No. 86124.

Oil Engines. S. M. Howell. General discussion with illustrated descriptions of types. 2000 w. Mach, N Y—Aug., 1907. No. 86143 C.

Progress in Oil Engines. E. F. Lake. Discusses wherein the oil engine excels the gasoline, its cost of operation and progress. Ills. 2500 w. Engr, U S A—Aug. 15, 1907. No. 86412 C.

Producer Plants.

Producer Gas Plant in Newark, N. J. Edward J. Kunze. Illustrates and describes a plant in which the same gas generated for feeding gas engines is made also to serve the burners of the annealing furnaces of a jewelry factory. 2000 w. Engr, U S A—Aug. 15, 1907. No. 86411 C.

Producer Plant for Lighting and Electric Drive. Illustrated description of a power plant of three vertical engines fed from one producer. 1500 w. Engr, U S A—Aug. 1, 1907. No. 86133 C.

Suction Gas Producer Plant at Rocky Ford, Colo. Illustrated description of an installation for operating a water and light plant. 700 w. Power—Aug., 1907. No. 86030 C.

Rating.

Horse-Power Rating of Gas Engines. Henry C. Hart. Explains a method of calculating the horse-power of any given engine. 1800 w. Gas Engrs' Mag—Aug. 15, 1907. No. 86620 A.

Testing.

The Testing of Large Gas Engines (Ueber Grossgasmaschinen und ihre Untersuchungen). Discusses the indicator diagram of the gas engine, and methods and appliances for testing, gas calorimeters and gas-analysis apparatus, with full calculations of actual tests. Ills. 5000 w. Glückauf—July 13, 1907. No. 86235 D.

HEATING AND COOLING.

Domestic.

Indirect System of Residence Heating. Plans and description of a low pressure gravity circulating system of steam heating, using the indirect system for the principal rooms, and the direct for rooms at a distance from the boiler. 1500 w. Met Work—Aug. 3, 1907. No. 86059.

Graphical Data.

Graphical Tables for Hot-Water Heating, Ventilating, and Chimney Design (Graphische Tafeln zur Berechnung von Warmwasserheizungen, Lüftungen und Schornsteinen). Herr Gramberg. Gives a number of curves showing graphically loss of pressure in pipes, etc., and with examples of their use. Ills. 6000 w. Gesundheits-Ing—July 6, 1907. No. 86265 D.

Hot-Water.

Rapid-Circulation Hot-Water Heating Systems (Warmwasser-Schnellumlaufheizungen). Ed. Meter. Read at the Heating and Ventilating Congress in Vienna, 1907. Illustrates and describes various systems. 6000 w. Gesundheits-Ing—July 20, 1907. No. 86267 D.

The Arrangement and Design of Piping in Hot-Water Heating with Special Reference to the Loss of Heat in Pipes (Anordnung und Bemessung der Rohrleitung bei Warmwasserheizungen mit Besonderer Berücksichtigung der Wärmeverluste im Rohrnetz). Ernst Lucas. A mathematical discussion with elaborate tables. Ills. 6500 w. Gesundheits-Ing—July 13, 1907. No. 86266 D.

Hygiene.

The Hygienic and Economic Importance of Heating and Ventilating Engineering (Die Gesundheitliche und Wirtschaftliche Bedeutung der Heizungs- und Lüftungstechnik). Karl Suwald. Read at the Congress of Heating and Ventilating Engineers at Vienna, 1907. 3500 w. Gesundheits-Ing—July 27, 1907. No. 86268 D.

Mechanical Equipment.

Mechanical Equipment of the New City Hall at Newark, N. J. Plan and description of the mechanical plant for a 4-story and basement building, having an unusual heating and ventilating system. 3500 w. Eng Rec—Aug. 17, 1907. Serail. 1st part. No. 86422.

Plenum System.

The Plenum System of Warm Air Heating for a School or Office Building. J. D. Hoffman. Read before the Am. Soc. of Heat. & Vent. Engrs. Aims to show how such a line of work could be accomplished. 2500 w. Dom Engng—Aug. 17, 1907. No. 86433.

Refrigeration.

Refrigeration as an Auxiliary to the Power Plant. Joseph H. Hart. Discusses the utilization of exhaust steam for the evaporation of ammonia in connection with the absorption process for

We supply copies of these articles. See page 239.

refrigeration. 1500 w. Cassier's Mag—Aug., 1907. No. 86006 B.

HYDRAULICS.

Annular Openings.

The Flow of Water Through Annular Spaces (Strömungsvorgänge in Ringförmigen Spalten). Ernst Becker. A mathematical paper, describing a series of tests to determine the values of coefficients used in the theoretical formulæ. Ills. 5000 w. Zeitschr d Ver Deutscher Ing—July 20, 1907. No. 86275 D.

Centrifugal Pumps.

Centrifugal Pumps. William O. Webber. Several types of pumps and their construction are illustrated and described. 1200 w. Engr, U S A—Aug. 1, 1907. No. 86131 C.

High-Pressure Machinery.

On the Design of Machinery for Very High Pressures. J. E. Petavel. An illustrated article discussing the special difficulties encountered at very high pressures. 1200 w. Engng—July 26, 1907. No. 86173 A.

Pumping Machinery for Dalny Water-Works. Illustrates and describes two sets of pumping engines of the vertical triple-expansion surface condensing type, which work three vertical plunger pumps. 700 w. Engr, Lond—Aug. 2, 1907. No. 86366 A.

Pumping Engines.

Two-Stage Operation of a Large Pumping Engine. A. O. Doane. Describes changes made in one of the engines of the Metropolitan Water-Works of Massachusetts as to enable it to be used in pumping to high service as well as low. Ills. 1000 w. Eng News—Aug. 29, 1907. No. 86630.

Pumping Plants.

Electric Pumping System. Illustrates and describes the system of electrically-driven pumping-plants for water supply and mine drainage recently installed at Walhalla, V. 2500 w. Aust Min Stand—July 12, 1907. No. 86154 B.

See also Civil Engineering, Municipal.

MACHINE WORKS AND FOUNDRIES.

Alloy Steels.

Heat Treatment of Alloyed Steels. E. F. Lake. Discusses methods of annealing, temperatures which are safe, ways of heating and quenching, and the effect of various alloy materials on steel. 4500 w. Am Mach—Vol. 30, No. 31. No. 86053.

Ball Bearings.

Designing a Three-point Ball Bearing. Describes the way to design the bearing and test the balls. 700 w. Am Mach—Vol. 30, No. 31. No. 86057.

Bell Yoke.

Tools for Manufacturing a Locomotive Bell Yoke. L. E. Salmon. Line engravings of a bell yoke and the fixture and small tools used in machining it, with description of work. 1000 w. Am Mach—Vol. 30, No. 33. No. 86385.

Boring Mill.

Work of the Floor-plate Boring Mill. Gives photographs and description of original shop methods at the Crocker-Wheeler Elec. Co.'s works. 700 w. Am Mach—Vol. 30, No. 33. No. 86378.

Brass.

Science Applied to the Brass Industry. Andrew M. Fairlie. Read before the Am. Found. Assn. Gives examples in proof of the benefit of scientific principles and methods applied in the brass foundry. 2000 w. Foundry—Aug., 1907. No. 86021.

Brass Oxidation.

Oxidizing Yellow Brass with the Production of a Black or Brown Color. J. W. Manson. Describes methods used by the writer and found satisfactory. 2500 w. Brass Wld—Aug., 1907. No. 86480.

Brass Works.

The Hygienic Aspect of Brass Melting and Casting. Erwin S. Sperry. On the dangers of metal poisoning and the diseases to which brass smelters are subject, giving rules proposed in England for maintaining brass shops in a sanitary condition. Ills. 3500 w. Brass Wld—Aug., 1907. No. 86479.

British Methods.

Advanced British Manufacturing Methods. Illustrations of interesting examples of repetition work in machine tool manufacture, with notes. 500 w. Mach, N Y—Aug., 1907. No. 86138 C.

Cams.

Notes on Cam Design and Cam Cutting. James L. Dinnany. Calls attention to points to be considered in designing and producing satisfactory cams. Ills. 2000 w. Mach, N Y—Aug., 1907. No. 86142 C.

Simplifying a Difficult Cam Job. States the problem and the solution. Ills. 800 w. Am Mach—Vol. 30, No. 31. No. 86054.

Case-Hardening.

Case-hardening the Alloy Steels. E. F. Lake. Shows that selecting the best alloys, the proper carbonizing materials, and giving the correct heat treatment secures satisfactory results. 3000 w. Am Mach—Vol. 30, No. 32. No. 86199.

Case Hardening (Einsetzen oder Oberflächenhärtung). Discusses the various problems of case hardening, packing, heating, etc., illustrating a case-hardening oven. 4000 w. Zeitschr f Werkzeugmasch u Werkzeuge—July 25, 1907. No. 86262 D.

We supply copies of these articles. See page 239.

Castings.

Aluminum Alloy Founding Practice. Hugh Dolnar. An illustrated article describing mixtures used and precautions taken to secure sound castings. 2500 w. Am Mach—Vol. 30, No. 34. No. 86506.

Casting Under Difficulties. Jabez Nall. Illustrates and describes the pouring a 50-ton forging machine frame with limited melting capacity and insufficient crane power. 1000 w. Foundry—Aug., 1907. No. 86016.

Chilled Castings in Iron. Walter J. May. Suggestions for the making of chilled castings. Ills. 900 w. Prac Engr—Aug. 2, 1907. No. 86349 A.

Iron Castings—Some Causes of Failure in Service. Robert Job. Read before the Am. Soc. for Test. Materials. Gives method pursued in ascertaining defects in locomotive castings and the remedies by which they were overcome. 1200 w. Foundry—Aug., 1907. No. 86017.

Malleable Castings. E. L. Rhead. The present article considers the effects of different ingredients and treatments. 5500 w. Mech Engr—Aug. 3, 1907. Serial. 1st part. No. 86350 A.

Sandless Castings. John H. Shaw. Read before the Am. Found. Assn. Describes the casting of brakeshoes in permanent molds that automatically provide for expression. Ills. 1000 w. Foundry—Aug., 1907. No. 86015.

Crank-Shaft.

Making a Six-throw Crank-shaft Out of a Solid Bar. John L. Bogert. Drawing and description, with cost of manufacture. 900 w. Am Mach—Vol. 30, No. 33. No. 86383.

Cutting Metals.

A Burner for Cutting Metals. M. U. Schoop. Explains the principle and describes the method, giving a summary of precautions which must be taken. 600 w. Elec-Chem & Met Ind—Aug., 1907. No. 86340 C.

Designing.

Graphic and Other Aids in Designing. Luther D. Burlingame. On the use of drawings and samples of various machine parts to aid draftsmen in determining sizes, etc., of component parts of machines. Ills. 1200 w. Am Mach—Vol. 30, No. 35. No. 86622.

Dies.

Dies for Making Square Pans. Julius F. A. Vogt. Sketches and description of the dies and their Use. 1200 w. Am Mach—Vol. 30, No. 34. No. 86507.

Making a Sub-press Die. H. M. Hyatt. Illustrated description of method. 1000 w. Am Mach—Vol. 30, No. 34. No. 86504.

Drying Stoves.

New Drying Stoves for Iron and Steel Foundries (Neuerungen an Trockenkammern für Eisen- und Stahlgiessereien). E. Freytag. Illustrated description of several types, particularly gas-fired stoves. 2000 w. Stahl u Eisen—July 24, 1907. No. 86230 D.

European.

Some Manufactories of Electrical and Other Machinery in Central Europe (Quelques Ateliers de Constructions Electriques et Mécaniques de l'Europe Centrale). Alfred Lambotte. Describes a large number of the more important works in France, Germany, Italy, Switzerland, etc., with notes on the electrical machines, pumps, turbines, engines, etc., produced. Ills. 35000 w. Soc Belge d'Electriciens—July, 1907. No. 86200 E.

Feeds.

Feeds and Feed Mechanisms. John Edgar. Considers the problem of feed variation for the lathe, for the milling machine, and for dependent and independent drives. 3500 w. Mach, N Y—Aug., 1907. No. 86135 C.

Files.

Files and Their Testing (Ueber Feilen und Ihre Prüfung). Illustrates and describes the file-testing machine built by Edward G. Herbert, Manchester, and methods of making tests. 2500 w. Zeitschr f Werkzeugmasch u Werkzeuge—July 5, 1907. No. 86261 D.

Flanging.

A Large Hydraulic Flanging Press. E. A. Dixie. Illustrates and describes how the flanged work for the P. R. R. system is produced by the use of a hydraulic press and cast-iron dies. 1500 w. Am Mach—Vol. 30, No. 33. No. 86381.

Fly-Wheels.

A Wire-wound Wood-rim Fly-wheel. E. E. Clock. Describes the building of these wheels. Ills. 1000 w. Power—Aug., 1907. No. 86031 C.

Foundries.

A Steel Foundry for Lumber Machinery Castings. Illustrated detailed description of a plant in Menominee, Mich., and its equipment. 2000 w. Ir Trd Rev—Aug. 1, 1907. No. 86033.

Messrs. R. Stephenson and Co.'s Foundry, Hebburn. Plan showing the position and arrangement, with illustrations and short description. 800 w. Engng—Aug. 16, 1907. No. 86600 A.

Gauges.

Adjusting Gauges by Peening. W. H. Booth. Suggestions for keeping gauges properly adjusted, stating objections to peening. 800 w. Am Mach—Vol. 30, No. 31. No. 86052.

Gears.

Calculations Respecting Epicyclic Wheel Trains. W. Owen. Gives a rule applicable to both spur- and bevel-geared

We supply copies of these articles. See page 239.

epicyclics, illustrating its application by examples. 1000 w. Am Mach—Vol. 30, No. 32. No. 86198.

Grading Steels.

The Spark Method for Grading Steels. Albert F. Shore. Describes a method depending on the action of oxygen in the air on the more combustible elements contained in different steels, which tend to act explosively when the proper temperature is reached. Ills. 1000 w. Am Mach—Vol. 30, No. 33. No. 86380.

Grinding.

Speeds on the Grinding Machine. H. F. Noyes. A brief study of speed conditions necessary to obtain the greatest output from a grinding machine, giving results of tests. 1500 w. Am Mach—Vol. 30, No. 34. No. 86505.

Vertical Spindle Surface Grinder. Illustrated detailed description of a machine of novel design and construction, utilizing a large cup wheel for rapidly and accurately grinding flat surfaces. 2500 w. Am Mach—Vol. 30, No. 31. No. 86051.

Hammers.

Compound Pneumatic Hammers. Illustrates and describes a recent design of English manufacture, giving interesting details of tests. 900 w. Engr, Lond—July 19, 1907. No. 86001 A.

Hammer Driving.

Compressed Air for Steam Hammers. Frank Richards. Considers the economy and expediency of employing compressed air for driving steam hammers, indicating the conditions under which it is advisable. 2500 w. Compressed Air—Aug., 1907. No. 86402.

Labor.

The Promotion of Employees. J. F. Gairns. Considers the relative importance of the various qualifications for promotion, aiming to give the main considerations which should govern an employer's policy. 4000 w. Cassier's Mag—Sept., 1907. No. 86615 B.

Management.

Profit Making in Shop and Factory Management. C. U. Carpenter. This eighth article of the series considers cost-keeping, stock-keeping and the wage system. 4000 w. Engineering Magazine—Sept., 1907. No. 86611 B.

Manganese.

Manganese in Cast Iron. Herbert E. Field. Read before the Am. Found. Assn. Discusses the effects of the use of manganese in increasing carbon and decreasing and neutralizing sulphur. 2000 w. Foundry—Aug., 1907. No. 86020.

Metal Ruptures.

The Formation of Cracks due to Expansion (Wärmespannungen und Rissbildungen). Carl Sulzer. Considers ruptures of engine cylinders due to unequal heating, the cracks developed in riveting boiler plates, etc. Ills. 3500 w. Zeitschr d Ver Deutscher Ing—July 27, 1907. No. 86255 D.

Milling Machine.

A Handy Milling Machine. Illustrated detailed description of the Farwell Quick Change Milling Machine. 1200 w. Am Mach—Vol. 30, No. 31. No. 86056.

Modern Practice.

Notes on Modern Engineering Works. R. D. Summerfield. Discusses modern practice under the headings of buildings, equipment and management. 4500 w. Mech Engr—Aug. 17, 1907. No. 86585 A.

Molding.

Entirely a Molding Machine Product. Henry M. Lane. Illustrates and describes the methods followed in making Becker-Brainard milling machine castings. 1200 w. Ir Age—Aug. 1, 1907. No. 86035.

Machine Molding of a Chaff-cutter Mouthpiece Casting. George Buchanan. Illustrated description of the casting and method of molding. 1400 w. Am Mach—Vol. 30, No. 35. No. 86627.

Pattern Making.

Shop Kinks or Short Cuts, and Dont's. Presented to the American Foundrymen's Association by the Cleveland Club of Associated Patternmaker Foremen. 3000 w. Foundry—Aug., 1907. No. 86019.

Patterns.

The Patternmaking of a Locomotive Cylinder. Jno. W. Wolfenden. Illustrated detailed description of method. 900 w. Am Mach—Vol. 30, No. 33. No. 86384.

White Metal Pattern Mixtures. S. T. McMurten. Gives the composition of various mixtures and some useful information. 800 w. Brass Wld—Aug., 1907. No. 86481.

Pattern Shop.

Arrangement of a Pattern Shop in a Confined Space. Oscar E. Perrigo. States the conditions and describes the arrangement. Plan. 1500 w. Foundry—Aug., 1907. No. 86018.

Pneumatic Tools.

Portable Pneumatic Tools. Herbert Bing. Illustrates and describes the improvements effected in the early tools and the most important new tools. 11000 w. Inst of Mech Engrs — July, 1907. No. 86353 N.

The Economic Importance of Compressed-Air Tools (Die Wirtschaftliche Bedeutung der Pressluftwerkzeuge). Alexander Lang. An elaborate analysis of operating costs showing under what circumstances they are economical. 3000 w. Zeitschr d Ver Deutscher Ing—July 20, 1907. No. 86277 D.

We supply copies of these articles. See page 239.

Production Records.

A Graphical Wall Record for the Production Department. H. L. Whittemore. Explains a system giving instant oversight of all work in progress, showing its advantages. Diagrams. 3000 w. Engineering Magazine — Sept., 1907. No. 86609 B.

Reamers.

Reamers. Erik Oberg. Deals principally with the purpose of reamers and the manner in which they are used, describing types. 2000 w. Mach, N Y—Aug., 1907. Serial. 1st part. No. 86140 C.

Riveting.

Hydraulic Riveting. E. W. de Rusett. Read at Bordeaux Int. Cong. On the use of hydraulic riveting in the construction of the "Mauritania." Ills. 1200 w. Engng—July 26, 1907. No. 86184 A.

Rods.

The Design of Eccentric Pull and Push Rods. H. M. Prevost Murphy. Gives an analysis of the two most common types. Diagrams. 1200 w. Am Mach—Vol. 30, No. 35. No. 86624.

Safety Appliances.

Safety Appliances on Speed-Frames in Cotton-Mills. Explains the dangers in cotton mills, especially to women and girls, and gives illustrated descriptions of recent safety appliances. 2500 w. Engng—Aug. 9, 1907. No. 86467 A.

Stoneywood.

The Stoneywood Paper Works. Illustrates and describes the interesting engineering features of these works, near Aberdeen, Scotland. 3000 w. Engr, Lond —Aug. 16, 1907. No. 86604 A.

Storage.

Storage in a Large Concrete Machine Shop. L. P. Alford. Illustrates and describes the fire-resisting racks, boxes and other storage devices in the plant of the United Shoe Machinery Co., at Beverly, Mass. 5000 w. Am Mach—Vol. 30, No. 32. No. 86196.

Thread Milling.

The Philadelphia Thread Milling Attachments. Illustrated description of a device which renders engine lathes capable of performing thread milling with facility. 1000 w. Ir Age—Aug. 8, 1907. No. 86115.

Tubes.

Rolling Seamless Tubes. Gives an account of the development of the Mannesmann tubes, and the phenomenon of the central rupture in cross rolling, describing present practice. Ills. 1800 w. Ir Age—Aug. 29, 1907. No. 86621.

Turning.

Turning a 12-inch Gun Roller Path. Gompei Kuwada. Illustrates and describes the method adopted. 1000 w. Am Mach—Vol. 30, No. 31. No. 86058.

Turret Attachment.

A Multiple-Spindle Tailstock for Turret Work on an Engine Lathe. Oscar E. Perrigo. Illustrates and describes a very useful and economical attachment which can be made in the shop. 1500 w. Am Mach—Vol. 30, No. 35. No. 86626.

Ventilation.

The Ventilation of Workshops. The second report of a Departmental Committee to the Home Secretary in regard to investigations made as to the ventilation of English factories, dealing especially with the application of fans for the removal of dust, fumes, steam and other impurities. Also the question of respirators. 3500 w. Mech Engr—Aug. 17, 1907. Serial. 1st part. No. 86587 A.

Welding.

An Improved Electric Welder. A. Frederick Collins. An illustrated description of the Prescott welder, especially designed for welding wire and rods of small cross section. 1200 w. Sci Am—Aug. 3, 1907. No. 86065.

Autogenous Welding. F. C. Cutler. Illustrated description of the oxy-acetylene blow-pipe and its application. 1800 w. Cassier's Mag—Sept., 1907. No. 86618 B.

Wire-Drawing.

Modern Practice in Wire-Drawing Machines. An illustrated review of the trend in the design of machines used for all classes of wire making. 2000 w. Engng—Aug. 9, 1907. Serial. 1st part. No. 86466 A.

Wooden Rolls.

Making Wooden Rolls for Textile Machinery. G. A. Dexter. Brief illustrated description of methods used by the writer. 700 w. Am Mach—Vol. 30, No. 32. No. 86300.

MATERIALS OF CONSTRUCTION.

Alloy Steels.

The Forging of Alloy Steels. E. F. Lake. Showing the effect of temperature, methods of forging, welding and annealing on the production of high-grade forgings. 3000 w. Am Mach—Vol. 30, No. 35. No. 86623.

Aluminum.

Cast Aluminum for Automobile Work. Thomas J. Fay. A discussion of this material, reporting tests, and giving information of interest. 2000 w. Automobile—Aug. 15, 1907. No. 86439.

Annealing.

Annealing High-Speed Steel. Ethan Viall. Gives replies to an inquiry sent to prominent makers of high speed steel as to the best way to anneal their particular brand. 1200 w. Am Mach—Vol. 30, No. 35. No. 86625.

Automobiles.

Gray Cast Iron in Auto Construction.

We supply copies of these articles. See page 239.

Thomas J. Fay. Discusses the uses for which it is suitable, explaining some of its characteristics. 3800 w. Automobile—Aug. 1, 1907. No. 86037.

Castings.

Experiments with Cylinder Irons. Reports experiments made by F. J. Cook with mottled irons for casting cylinders, also with hematites and phosphoric irons for ordinary castings. 1600 w. Ir & Coal Trds Rev—Aug. 9, 1907. No. 86478 A.

Locomotives.

The Use of Steel in Locomotive Construction. F. A. Lart. Discusses the use of the newer and much stronger steel alloys for the construction of locomotives, with a reduction in the proportions and weights of their individual parts. 3500 w. Cassier's Mag—Sept., 1907. No. 86617 B.

MEASUREMENT.

Drop Test.

The Actual Status of the Drop Test on Nicked Bars (Ueber den Gegenwärtigen Stand der Schlagbiegeprobe mit Eingekerbten Stäben). A discussion of this method of testing, outlining the researches which have been made as to its accuracy and utility. 2500 w. Serial. 1st part. Stahl u Eisen—July, 31, 1907. No. 86232 D.

Indicator Cards.

See also Marine Engineering.

Measuring Machines.

Making a Dial Measuring Machine. Oscar E. Perrigo. Illustrated description of the machine and its use. 2500 w. Am Mach—Vol. 30, No. 33. No. 86382.

Pressure Gauges.

History and Construction of Pressure Gauges. C. E. Stromeyer. From the annual memorandum issued by the Chief Engineer to the Manchester Steam Users' Assn. Gives the history of the development of pressure gauges, and describes various instruments. 4000 w. Mech Engr—Aug. 17, 1907. Serial. 1st part. No. 86586 A.

Pyrometry.

The Electrical Measurement of Temperature (Misura Elettrica delle Temperature). A discussion of the theory of electrical pyrometry with brief details of construction and operation of various systems. 2100 w. Elettricita—July 12, 1907. No. 86216 D.

The Thwing Electric Pyrometers. Illustrated detailed description of types of this radiation pyrometer. 1800 w. Ir Age—Aug. 1, 1907. No. 86036.

Testing Machines.

An Electrically Controlled Single-Lever Testing-Machine and Some Torsion Tests. Charles E. Larard. A full illustrated description of the essential parts of the latest of J. Hartley Wicksteed's testing machines. 6000 w. Inst of Mech Engrs—July, 1907. No. 86355 N.

New Machines and Methods for the Testing of Metals (Nouveaux Mécanismes et Nouvelles Méthodes pour l'Essai des Metaux). Pierre Breuil. The first instalment illustrates and describes various types of extensometer. 8500 w. Serial. 1st part. Rev d Mécan—June 30, 1907. No. 86206 E + F.

Water Gages.

Water Level Gages. Robert E. Horton. Illustrates and describes styles of river gages designed by the writer. 1300 w. Eng News—Aug. 22, 1907. No. 86514.

POWER AND TRANSMISSION.

Belts.

Power Transmission by Belts and Ropes (Cinghie e Corde per Trasmissioni). Gino Scanferia. The first part discusses the stretching of leather and the theory of belt design. 3000 w. Serial. 1st part. Il Monit Tec—July 20, 1907. No. 86219 D.

Cableways.

Cableways Used on Shipbuilding Berths. John M. Henderson. An illustrated description of the equipment of the Jarrow Yard, for handling heavy material. 5 plates. 2500 w. Inst of Mech Engrs—July, 1907. No. 86352 N.

Coal Storage.

Some Recent Mechanical Coal Storage Plants. Wilbur G. Hudson. Discusses storage of anthracite and bituminous coal, the systems installed, etc. Ills. 4000 w. Eng News—Aug. 29, 1907. No. 86628.

Costs.

Comparative Cost of Steam and Hydro-Electric Power. William O. Webber. A commentary and supplement to Mr. H. von Schon's discussion, giving cost data from actual experience with working installations. 1000 w. Engineering Magazine—Sept., 1907. No. 86608 B.

Comparative Costs of Gasoline, Gas, Steam, and Electricity for Small Powers. William O. Webber. Gives tables of itemized cost of 1 H. P. per hour on 2, 6, 10 and 20 H. P. plants respectively for gasoline, gas, steam, and electricity. 1200 w. Eng News—Aug. 15, 1907. No. 86388.

Relative Economy of Steam and Gas Power Where Exhaust Steam is Used for Heating. F. W. Ballard. Read before the Ohio Soc. of Mech., Elec., & Steam Engrs. A comparison showing that when the exhaust steam is utilized, steam is more economical. 3000 w. Eng News—Aug. 15, 1907. No. 86387.

Cranes.

A Comparison Between Hydraulic and Electric Cranes (Comparaison entre les Grues Hydrauliques et les Grues Electriques). R. Gasquet. Describes the mechanism of both types and compares their operation, with especial reference to their

We supply copies of these articles. See page 239.

utility on docks. Ills. 4000 w. Serial. 1st part. Génie Civil—July 27, 1907. No. 86213 D.

Electric Driving.

Plant of the Manz Engraving Company. Illustrated description of a modern engraving and printing plant equipped with individual electric drive. 1500 w. Engr, U S A—Aug. 15, 1907. No. 86409 C.

Rope Driving.

Investigations of Belt and Rope Driving (Versuche mit Riemen und Seiltrieben). Herr Kammerer. Describes the specially constructed machine on which the tests were made, the tests themselves, and the results. Ills. 7000 w. Zeitschr d Ver Deutscher Ing—July 13, 1907. No. 86271 D.

Transport Devices.

Hoisting and Transport Devices in Steelworks and Rolling Mills (Hebe- und Transportmittel in Stahl- und Walzwerksbetrieben). G. Stauber. Gives elaborate illustrations and detail drawings of various types of molten-metal conveyors, cranes for handling ingots, etc. 25000 w. Stahl u Eisen—July 10, 1907. No. 86224 D.

Worm Gearing.

Calculating the Dimensions of Worm Gearing. Ralph E. Flanders. A compilation of rules. Ills. 2500 w. Mach, N Y—Aug., 1907. No. 86137 C.

STEAM ENGINEERING.

Boiler Explosion.

Keir Explosion at Maypole. A report of the investigation of a boiler explosion on Feb. 18, 1907, at the Agricultural Implement Works of A. Jack & Sons, Ltd. 2200 w. Engng—July 26, 1907. No. 86186 A.

Boiler Plates.

The Rupture of Boiler Plates (Zur Frage der Rissbildung in Kesselblechen). Suggests improvements in materials, processes of manufacture, and methods of testing, illustrating their necessity and utility from actual examples of failure. Ills. 3500 w. Stahl u Eisen—July 3, 1907. No. 86225 D.

Boiler-Room Design.

Boiler-Room Design and Equipment. William H. Bryan. An illustrated article discussing in detail the present trend of practice and the controlling ideas which should govern the design. 2500 w. Cassier's Mag—Sept., 1907. No. 86619 B.

Boilers.

The Piping and Fittings for a Tubular Boiler. F. C. Douglas Wilkes. Methods of determining the size of the steam opening, the safety valve, etc., are considered in the present article. Ills. 1800 w. Boiler Maker—Aug., 1907. Serial, 1st part. No. 86042.

Economics.

Notes on Steam Plant Operation. Howard Williams. Considers both land and marine practice and the strict attention to every possible source of loss or gain needed to secure satisfactory results. 1800 w. Elec Wld—Aug. 3, 1907. No. 86152.

Engine Adjustment.

Adjusting the Sturtevant Compound Engine. Carl S. Dow. An illustrated article giving directions for setting valves and adjusting the governor and drainage systems of the vertical cross-compound type. 2000 w. Power—Aug., 1907. No. 86024 C.

Engine Breakdown.

An Engine Wreck. P. F. Walker. An illustrated account of an accident to a vertical cylinder. 1000 w. Engr, U S A—Aug. 15, 1907. No. 86410 C.

Engines.

Estimation of the Unbalanced Forces in Multi-Cylinder One-Crank Engines. Archibald Sharp. An investigation of the unbalanced forces in an engine of this type. 4000 w. Inst of Civ Engrs—No. 3658. No. 86374 N.

Mary. An illustrated description of a new compound piston drop valve engine recently installed in the Huddersfield Corporation Electricity Works. 2500 w. Engr, Lond—July 19, 1907. No. 85999 A.

Exhaust Steam.

The Utilization of Exhaust Steam by Accumulators and Low-Pressure Turbines (Utilisation des Vapeurs d'Echappement par Accumulateurs et Turbines à Basse Pression). E. Cornez. Describes the system devised by M. A. Rateau, illustrating installations and giving details of working. 4500 w. L'All Indus—July, 1907. No. 86201 D.

Utilization of Exhaust Steam for Power Generation. T. Rich. Concerning exhaust steam turbines and the work for which they are adapted. 1500 w. Ir & Coal Trds Rev—Aug. 9, 1907. No. 86477 A.

Feed Water.

See also Marine Engineering.

Feed-Water Heaters.

Heat Transmission in the Heating Surfaces of Feed-Water Heaters (Der Wärmeübergang an Vorwärmerheizflächen). Paul Fuchs. Gives results of elaborate tests. 3000 w. Zeitschr d Ver Deutscher Ing—July 13, 1907. No. 86273 D.

Flash Steam.

The Flash Steam Generator. H. W. Bolsover. Discusses this method, especially in connection with the design of automobile vehicles, showing it to be applicable for such purposes. 1600 w. Cassier's Mag—Sept., 1907. No. 86616 B.

Flue Gases.

Apparatus for Analyzing Flue Gases. Illustrates and describes Bement's improved Orsat apparatus, and Wilson's portable gas-analysis apparatus. 1200 w. Power—Aug., 1907. No. 86029 C.

We supply copies of these articles. See page 239.

Fuel Losses.

Fuel Losses in Steam Power Plants. George H. Barrus. Discusses the more important losses as indicated by actual tests and examinations. 4500 w. Cassier's Mag—Aug., 1907. No. 86008 B.

Gas Firing.

Producer Gas for Firing Steam Boilers. A. M. Gow. Gives the writer's opinion as to why producer gas is not a suitable fuel for steam boilers. Ills. 2000 w. Power—Aug., 1907. No. 86025 C.

Injectors.

The Operation and Care of Injectors. W. H. Wakeman. A practical discussion of the leading types, explaining their action and the most approved methods of connecting. Ills. 2500 w. Power—Aug., 1907. No. 86027 C.

Isolating Valves.

Tests of Isolating Valves for Steam-Pipes. A brief account of tests made in Germany, taken from Dr. Koehler's illustrated monograph. 1600 w. Engng—July 19, 1907. No. 85993 A.

Liquid Fuel.

Kermode's Liquid-Fuel System Applied to Babcock and Wilcox Boilers. Illustrates and describes an installation of this system which has been successfully at work at the Toula Brass Works in St. Petersburg. 1500 w. Engng—July 19, 1907. No. 85994 A.

Rotary Engines.

Rotary Engines (Rotationskraftmaschinen). Leo Russmann. Illustrates and describes numerous types. 3500 w. Elektrotech u Maschinenbau—July 14, 1907. No. 86251 D.

Safety Appliances.

Safety Appliances in the Engine Room. William Wallace Christie. Calls attention to dangers due to increasing use of power machinery, illustrating results of disasters, and giving illustrated descriptions of special safety appliances for use in the engine room. 3000 w. Cassier's Mag—Aug., 1907. No. 86009 B.

Smoke Abatement.

Boiler Room Economy. Paul M. Chamberlain. Abstract of lecture before the International Assn. for the Prevention of Smoke. Discusses means of securing perfect combustion, losses, and the stoker as a smoke abater. 2500 w. Engr, U S A—Aug. 1, 1907. No. 86132 C.

Stacks.

The Layout and Construction of Steel Stacks. An illustrated article discussing methods of anchoring of self-supporting stacks, details of riveting, and other features of the construction. 2500 w. Boiler Maker—Aug., 1907. No. 86041.

Steam Flow.

The Dynamics of the Flow of Steam in Reciprocating Engines (Dynamique de l'Ecoulement de la Vapeur dans les Machines à Pistons). W. Schüle. A translation from *Zeitschrift des Vereines Deutscher Ingenieure*. Ills. 10,000 w. Serial. 1st part. Rev d Mécan—June 30, 1907. No. 86207 E + F.

Steam Properties.

A Useful Diagram of Steam Properties. H. F. Schmidt and W. C. Way. Gives a diagram from which may be found the physical properties of moist and superheated steam at different pressures and temperatures. 3500 w. Power — Aug., 1907. No. 86028 C.

Turbines.

A Technical Review of the Development of the Steam Turbine and Turbo-dynamo (Dampfturbinen und Turbodynamos in Betriebstechnischer Hinsicht). F. Niethammer. The first part of the serial reviews the progress of the turbine. Ills. 4000 w. Serial. 1st part. Elektrotech u Maschinenbau—July 21, 1907. No. 86252 D.

Multi-Stage Steam Turbines with Impulse Effect (Mehrstufige Dampfturbinen mit Aktionswirkung). H. Wagner. An illustrated discussion of the action of Rateau and Zoelly turbines. 2000 w. Zeitschr f d Gesamte Turbinwesen—July 10, 1907. No. 86260 D.

The Modern Steam Turbine. Arnold Frean Harrison. A general description of the best known types of this class of prime mover, with some of the reasons for the construction peculiar to each. Ills. 3500 w. Inst of Civ Engrs (Student's Paper, No. 572). No. 86376 N.

See also Marine and Naval Engineering.

MISCELLANY.

Aeronautics.

A German Dirigible Air Ship: the "Zeppelin" (Un Dirigeable Allemand: le "Zeppelin"). G. Espitallier. Describes the ship and a series of elaborate tests to which it was recently subjected. Ills. 2000 w. Génie Civil—July 6, 1907. No. 86210 D.

The International Kite Ascensions. S. P. Fergusson. An illustrated account of the work in meteorological aeronautics carried out by the International Commission. 2000 w. Sci Am—Aug. 10, 1907. No. 86302.

The Use of Hydrolith for the Inflation of Balloons. Dr. G. F. Jaubert. Information in regard to this chemical compound and its manufacture. 1000 w. Sci Am—Aug. 3, 1907. No. 86063.

An Aeronautical Observatory. Dr. Alfred Gradenwitz. Illustrated description of an institution recently erected in the Prussian province of Brandenburg. 1500 w. Sci Am Sup—July 13, 1907. No. 85520.

Santos Dumont's Combined Aeroplane

and Airship. An illustrated account of experimental work near Paris. Refers briefly to recent work of other experimenters. 1400 w. Sci Am—July 6, 1907. No. 85411.

The Use of the Gyroscope in the Balancing and Steering of Aeroplanes. Robert H. Goddard. Describes an apparatus and its application to aeroplanes, explaining the controlling action. Ills. 700 w. Sci Am Sup—June 29, 1907. No. 85318.

Captive Balloons in the German Army and Navy. Dr. Alfred Gradenwitz. Gives an illustrated description of the improved type of balloon now being used, and an account of experiments recently made in locating submarine boats. 1500 w. Sci Am—July 13, 1907. No. 85518.

To the North Pole in a Dirigible Balloon (Au Pole Nord en Ballon Dirigeable). Lieut. Graham. An illustrated description of the balloon in which Wellman will make his second attempt to reach the Pole during the present year. 800 w. Génie Civil—June 8, 1907. No. 85615 D.

Centrifugal Fans.

High-Pressure Centrifugal Fans. A. Rateau. Reports experiments made to determine how far centrifugal fans could be driven under the best conditions as regards mechanical efficiency. 4500 w. Engng—Aug. 16, 1907. Serial. 1st part. No. 86601 A.

Cylinders.

Design of Thick Cylinders. T. A. Marsh. Considers the design of thick cylinders for pressures above 1000-lbs. per square inch, with special reference to hydraulic press cylinders. 1000 w. Mach, N Y—July, 1907. No. 85483 C.

Elevators.

The Growth and Development of the Elevator Industry. Charles H. Kloman. Reviews the rapid development of this industry, showing the changes through which it has passed, and the types to be installed in buildings of 40 stories or more. Ills. 2000 w. Cassier's Mag—Sept., 1907. No. 86613 B.

Energy.

The Energy Problem of the Universe. A. H. Gibson. Considers the forms which the prime mover has passed through and those to which evolution may ultimately tend, the present known sources of energy, etc. 6000 w. Cassier's Mag—Sept., 1907. No. 86612 B.

Gyroscope.

The Gyroscope. C. M. Broomall. From the Pro. of the Delaware Co. Inst. of Science. An explanation of the action of the gyroscope without mathematics. 5000 w. Sci Am Sup—Aug. 10, 1907. No. 86304.

Jute Machinery.

Observations on Present-Day Practice in Jute Preparing and Spinning. D. J. Macdonald. Describes a new method of driving the spindles with the view to saving power, changes in pressing rollers, transmission gear, etc. Ills. 2500 w. Inst of Mech Engrs—July, 1907. No. 86356 N.

Kinematics.

The Newman Kinematic Apparatus. Illustrates and describes a contrivance which simplifies the study of mechanisms. 1000 w. Sci Am Sup—Aug. 24, 1907. No. 86518.

Laboratory.

The New Engineering Laboratory at the City and Guilds of London Institute, Finsbury. Prof. E. G. Coker. Illustrated description. 1500 w. Engng—Aug. 16, 1907. No. 86599 A.

Lubricants.

Deflocculated Graphite. Edward G. Acheson. Gives an account of experimental investigations, and results. 1200 w. Pro Am Inst of Elec Engrs—July, 1907. No. 86537 D.

Moments of Inertia.

A Diagram for Calculating Moments of Inertia. O. A. Thelin. Gives a diagram designed to simplify calculations relative to moments of inertia of sections, explaining its use. 600 w. Am Mach—Vol. 30, No. 33. No. 86379.

Needle Machine.

Automatic Needle-Making Machinery. Photographs and description of an interesting machine for finishing sewing machine needles after they have been shaped. 1200 w. Mach, N Y—Aug., 1907. No. 86141 C.

MINING AND METALLURGY

COAL AND COKE.

Anthracite.

New Supplies of Anthracite Coal. W. E. Joyce. A report of some recent discoveries which upset established geological theories. 1500 w. Eng & Min Jour—Aug. 3, 1907. No. 86106.

Briquetting.

Progress in the Briquetting of Coal (Fortschritte im Kohlenstampfverfahren). A. Thau. Describes and illustrates recent machines and processes for this purpose. 4500 w. Glückauf—July 27, 1907. No. 86240 D.

We supply copies of these articles. See page 239.

Coke.

The Manufacture of Coke from Western Coal. R. S. Moss. Suggestions for coking these coals, showing the necessity of using crushed coal and raising the temperature of the oven very rapidly. Ills. 1500 w. Min Wld—Aug. 17, 1907. No. 86446.

The Carbonization of Durham Coking Coal. Andrew Short. Abstract of paper read before the Newcastle Sec. of the Soc. of Chem. Ind. Describes investigations carried out on a battery of patent coke ovens of the Otto-Hilgenstock type. 1800 w. Ir & Coal Trds Rev—July 19, 1907. No. 86004 A.

Colliery.

The Baggeridge Colliery. James Tonge. An account of the development of a new area of the thick coal of South Staffordshire, England. 2500 w. Mines & Min—Aug., 1907. No. 86100 C.

Collinsville, Ill.

Mine No. 17, Collinsville, Ill. Illustrates and describes the plans and arrangement of a mine having a capacity of 3,000 tons of coal per day, and the washery for preparing it. 1000 w. Mines & Min—Aug., 1907. No. 86097 C.

Crushing Strength.

The Ultimate Crushing Strength of Coal. Joseph Daniels and L. D. Moore. Describes tests made to determine the resisting power of anthracite and bituminous coals, in connection with a study of the size of coal-mine pillars. Ills. 2500 w. Eng & Min Jour—Aug. 10, 1907. No. 86335.

Electrical Equipment.

Allis-Chalmers Machinery Used in Coal and Coke Operations. W. B. Spellmire. Brief illustrated description of the York Run plant of the H. C. Frick Coke Co. 1000 w. Elec Rev, N Y—Aug. 24, 1907. No. 86547.

Explosions.

Colliery Warnings. A detailed examination of the value of colliery warnings, based upon barometric pressure, with an account of prevalent opinions. 4500 w. Col Guard—Aug. 9, 1907. No. 86465 A.

Geology.

Palaeontological Methods and Results in Coal Measure Geology. J. T. Stobbs. Abstract of an address before the So. Staffordshire Min. School Old Boys' Soc. 3500 w. Ir & Coal Trds Rev—July 19, 1907. No. 86003 A.

Peat.

The Technical Utilization of Bogs (Ein Beitrag zur Technischen Ausnutzung der Moore). N. Caro. Discusses the practicability of using peat as a fuel. 1800 w. Glückauf—July 13, 1907. No. 86237 D.

Prospecting.

Variability of Coal Seams. Arthur Lakes. Explains the cause, and the necessity of many bore holes at varying distances to prove the value of an area. 800 w. Min Wld—Aug. 3, 1907. No. 86114.

Rescue Appliances.

The "Westfalia" Rescue Apparatus (Der Rettungsapparat "Westfalia"). Herr Grahn. Illustrated detailed description of this recent German device, with results of tests. 1500 w. Glückauf—July 6, 1907. No. 86233 D.

Testing.

Recent Testing of Coal Used by the Federal Government in Its Public Buildings at Washington, D. C. J. A. Holmes. Explains methods of sampling at mines and on cars, and gives analyses of coals tested. 1500 w. Mines & Min—Aug., 1907. No. 86098 C.

Washing.

Bituminous Coal Washing. G. R. Delamater. Shows the wonderful growth of the bituminous coal industry, discussing methods of removing impurities, conditions of mining, testing, etc. 6000 w. Mines & Min—Aug., 1907. Serial. 1st part. No. 86095 C.

COPPER.

British Columbia.

Mining in the Boundary Copper Field. Ralph Stokes. Map and illustrated account of the mines and methods. 3500 w. Min Wld—Aug. 3, 1907. No. 86112.

The Britannia Copper Mine, British Columbia. Ralph Stokes. Notes based on a brief inspection of the plant, and data furnished. Ills. 1300 w. Min Wld—Aug. 17, 1907. No. 86445.

The Industrial Outlook of Boundary Copper Field. Ralph Stokes. A review of the development and progress, considering the outlook encouraging. Ills. 1800 w. Min Wld—Aug. 10, 1907. No. 86324.

California.

The Ore-Deposits of Copperopolis, Calaveras Co., California. John A. Reid. The location, history, topography and general geology are reviewed, and the deposits described. 13700 w. Ec Geol—June, 1907. No. 86487 D.

Electrolytic Refining.

Ryan Process for Making Electrolytic Copper. John H. Ryan. Describes the process, giving approximate cost of a plant. 600 w. Min Rept—Aug. 8, 1907. No. 86331.

Lake Superior.

Early History of the Lake Copper Region. A brief interesting account of the earliest information in regard to these deposits, and the development from 1830 to 1870. 1400 w. Min Wld—Aug. 10, 1907. No. 86325.

Nevada.

The Ely Copper Deposits and Their

We supply copies of these articles. See page 239.

Rapid Development. William Starr Bullock. An illustrated account of these extensive deposits and their development. 1500 w. Min Wld—Aug. 10, 1907. No. 86323.

Nicaragua.

Copper Ores in Nicaragua and Their Treatment. Information concerning this metal and its occurrence on the Escondido River and its tributaries. 3000 w. Min Jour—July 27, 1907. No. 86172 A.

Rolling.

The Rolling of Sheet Copper. Describes the style of rolling-mills used, and the general methods used in the manufacture. 3000 w. Ir Age—Aug. 22, 1907. No. 86502.

Smelting.

Briton Ferry Works of the Cape Copper Co. Edward Walker. Illustrates and describes the methods of treatment at these copper smelting works in South Wales. 1000 w. Eng & Min Jour—Aug. 17, 1907. No. 86428.

Negative Results in Pyritic Smelting. G. F. Beardsley. Describes an attempt made to treat, by pyritic smelting, the copper-nickel ores of the Sudbury district, Ontario, Canada. An account of the furnaces used and their construction; the tests made and the results obtained. 1500 w. Eng & Min Jour—Aug. 24, 1907. No. 86549.

Smelting Plants.

The Largest Copper Smelting Plant in the World From a pamphlet issued by the Anaconda Copper Mining Co. describing the Washoe smelter. Ills. 3000 w. Eng News—Aug. 1, 1907. No. 86075.

The Mining and Smelting Equipment of the Canadian Copper Company. David H. Browne. Illustrated description of the plants in operation and under construction for the treatment of copper-nickel ores. Electric power is used, also compressed air and steam. 5000 w. Can Min Jour—Aug. 1, 1907. No. 86127.

Wyoming.

Copper Deposits of Hartville Uplift, Wyoming. Sydney H. Ball. The present number describes the ore deposits. 1700 w. Min Rept—Aug. 8, 1907. Serial. 1st part. No. 86330.

GOLD AND SILVER.

Assaying.

The Litharge Method. B. M. Snyder. Gives the writer's experience with the litharge method of fire-assay. 1600 w. Min Rept—Aug. 1, 1907. No. 86111.

Black Sands.

Black Sands of the Pacific Coast. Dr. David T. Day. An interesting account of the investigations made, with information of methods of analysis and concentration and the valuable by-products found. 4500 w. Jour Fr Inst—Aug., 1907. No. 86343 D.

The Black Sand Problem. F. Powell. A suggestion from personal experience for an effective method of collecting black sand. 1200 w. Eng & Min Jour—Aug. 10, 1907. No. 86333.

Burma.

The Auriferous Deposits of Burma. Malcolm Maclaren. Sketch map showing localities, with brief review of the history of gold exploration in Burma. 2500 w. Min Jour—July 27, 1907. No. 86171 A.

Cobalt.

Vein Formation at Cobalt, Ontario. J. B. Tyrrell. Discusses these ore deposits, giving opinions of writers of note, and the writer's conclusions. Ills. 2000 w. Can Min Jour—Aug. 1, 1907. No. 86126.

The Cobalt Silver Field as an Industry. Ralph Stokes. The first of a series of articles aiming to give facts in regard to present conditions. Ills. Also editorial. 3500 w. Min Wld—Aug. 24, 1907. Serial. 1st part. No. 86571.

Colorado.

Lodes in the Tertiary Eruptions of Colorado. T. A. Rickard. Describes the geology and considers the deposits of gold and silver. Ills. 2000 w. Min & Sci Pr—Aug. 10, 1907. No. 86407.

Cyanide Plant.

A Cheap Form of Cyanide Plant. Charles Hunter. Gives a copy of the contract and specifications for one of the portable plants used in Southern Rhodesia. 1000 w. Inst of Min & Met, Bul 34—July 18, 1907. No. 86496 N.

Egypt.

Gold Mining in Egypt. C. S. Herzig. An illustrated article reviewing the history of the gold-mining industry in Egypt. 2000 w. Min & Sci Pr—Aug. 17, 1907. No. 86524.

Filter Press.

The Kelly Filter Press. D. J. Kelly. Describes a development of pressure filtration for the treatment of slimes and the operation of a plant on the Kelly System. 2000 w. Min Rept—Aug. 22, 1907. No. 86569.

Klondike Placers.

Concentration of Gold in the Klondike. J. B. Tyrrell. Describes the conditions that prevail in the Klondike district, studying the rich placers, their origin and concentration. Ills. 2000 w. Ec Geol—June, 1907. No. 86484 D.

Milling.

Stamp-Mill Reduction-Plant of the New Kleinfontein Company, Limited, Witwatersrand, Transvaal. Edward John Way. An illustrated detailed description of a new 200-stamp mill installation designed to use mechanical means wherever hand-labor could be dispensed with. Appendices. 23500 w. Inst of Civ Engrs—No. 3631. No. 86373 N.

We supply copies of these articles. See page 239.

Mining.

Present Status of the Gold Mining Industry. J. H. Curle. A review of the present conditions in all parts of the world where gold is produced. 3300 w. Min & Sci Pr—Aug. 3, 1907. No. 86189.

Nevada.

Pioche, Nevada. James W. Abbott. Gives the history of the discovery and development of this silver region. Ills. 2500 w. Min & Sci Pr—Aug. 10, 1907. No. 86406.

The Goldfield District, Nevada. Abstract of paper by J. E. Spurr, giving information of the geology of this district. 2000 w. Jour Fr Inst—Aug., 1907. No. 86344 D.

Placers.

The Essential Data of Placer Investigations. J. P. Hutchins. Calls attention to points to be ascertained and precautions to be taken in the examination and valuation of placer ground before exploitation. Ills. 2500 w. Eng & Min Jour—Aug. 24, 1907. Serial. 1st part. No. 86548.

The Nomenclature of Modern Placer Mining. J. P. Hutchins. Discusses the classification of placers, their origin, and methods of exploitation. Ills. 2000 w. Eng & Min Jour—Aug. 17, 1907. No. 86426.

Separator.

Combined Ore Crusher, Pulverizer, Retort and Bullion Separator. A combined arrangement for a continuous operation on any kind of ore is illustrated and described. 800 w. Min Rept—Aug. 22, 1907. No. 86570.

Slimes.

The Utilization of Waste Heat in Slimes Settlement. A. Salkinson. Describes trials made with encouraging results. 2500 w. Jour Chem, Met & Min Soc of S Africa—June, 1907. No. 86448 E.

IRON AND STEEL.

Blast Furnaces.

Charging a Modern Iron Blast Furnace. Bradley Stoughton. Considers the variations required in the charge of the furnace to produce the required results in pig iron. 1200 w. Eng & Min Jour—Aug. 24, 1907. No. 86551.

The Chemistry of the Iron Blast-Furnace. Bradley Stoughton. Traces the successive chemical reactions which occur as iron ore is reduced to pig iron. Ills. 1500 w. Eng & Min Jour—Aug. 3, 1907. No. 86104.

The Operation of the Iron Blast Furnace. Bradley Stoughton. Outlines the working of the furnace when in blast, giving an account of some difficulties encountered. 2000 w. Eng & Min Jour—Aug. 17, 1907. No. 86429.

Blowing Engines.

Parson's Turbine Blower as a Blast-Furnace Blowing Engine (Das Turbinengebläse von C. A. Parsons als Hochofengebläsemaschine): Julius Fürstenau. Enumerates and gives details of the plants at which this blower is used, with results of tests and remarks on accessory devices, etc. Ills. 5500 w. Zeitschr d Ver Deutscher Ing—July 20, 1907. No. 86274 D.

The Parsons Turbo-Blower for Blast Furnaces. Illustrated description of an installation at the Trzynietz furnace plant, as given by Julius Fuerstenau, in the *Zeit. des Ver. Deut. Ing.* 1500 w. Ir Age—Aug. 22, 1907. No. 80499.

Cuba.

The Mayari Iron Ore District of Cuba. Information concerning this remarkable deposit, estimated to contain over 500,000,000 tons, and some of the problems in the handling and treatment of the ore. Maps and Ills. 4500 w. Ir Age—Aug. 15, 1907. No. 86377.

Electric Smelting.

Electrical Smelting of Iron Ore. Brief account of the recent successful experimental run of the Héroult electrical smelting plant in Shasta Co., Cal. 600 w. Min Rept—Aug. 8, 1907. No. 86329.

Electric Smelting of Iron Ore in California. Gives a summary of an article describing the application of the Héroult Process to the smelting of iron from the large magnetite deposits. Also an editorial "Electric Heat versus Heat from Fuel." 2000 w. Elec Chem & Met Ind —Aug., 1907. No. 86339 C.

Impurities.

The Nonmetallic Impurities in Steel. Reviews the investigations by E. F. Law, of London. 1600 w. Ir Age—Aug. 22, 1907. No. 86501.

Lake Superior.

Mining Methods on the Gogebic Iron Range. Reginald Meeks. Describes the exploratory methods, the steel shafts and headframes which are replacing wooden construction, etc. Ills. 1400 w. Eng & Min Jour—Aug. 10, 1907. No. 86332.

The Iron-Ore Mines of the Mesabi Range. Reginald Meeks. An illustrated account of mines opened in 1892, which now produce 62 per cent. of the total ore from the northern ranges. 2200 w. Eng & Min Jour—Aug. 3, 1907. No. 86101.

Metallography.

The Present Condition of Our Knowledge of the Hardening and Cooling Phenomena in Iron-Carbon Alloys (Ueber den Augenblicklichen Stand unserer Kenntnisse der Erstarrungs- und Erkaltungsvorgänge bei Eisenkohlenstofflegierungen). P. Goerens. Illustrated by micro-photographs. 2500 w. Stahl u Eisen—July 24, 1907. No. 86229 D.

We supply copies of these articles. See page 239.

Phosphorus.

The Estimation of Phosphorus in Steel and Iron. J. J. Morgan. Describes a method by which a determination in steel may be made in 30 minutes without the use of any special apparatus. 800 w. Prac Engr—Aug. 16, 1907. No. 86583 A.

Piping.

The Avoidance of Piping (Zur Frage der Vermeidung von Lunkerbildung). Adalbert Obholzer. A description of the results obtained at the Diosgyör steelworks, Hungary, from the use of thermit. Ills. 2300 w. Serial. 1st part. Stahl u Eisen—July 31, 1907. No. 86231 D.

Segregation.

Segregation in Steel. Abstract of a paper by John E. Stead, read at the Engng. Con. of the Inst. of Civ. Engrs. Results of an investigation. 1200 w. Ir Age—Aug. 8, 1907. No. 86116.

Smelters.

The Plants of the Luxemburg Mining, and Saarbrück Smelting Company (Die Anlagen der Luxemburger Bergwerks- und Saarbrücker Eisenhütten-Aktiengesellschaft). F. Schroeder. The first part of the serial reviews the history of this German company from its formation in 1856. Ills. 3000 w. Serial. 1st part. Oest Zeitschr f Berg u Hüttenwesen—July 27, 1907. No. 86249 D.

MINING.

Air Compressors.

A New Development in Air Compressors. Illustrated description of the Nordberg constant speed variable delivery air compressor. 1200 w. Am Mach—Vol. 30, No. 34. No. 86503.

Bore-holes.

The Deviation of Rand Bore-holes from the Vertical. Joseph Kitchin. Gives the results of the surveys of 22 bore-holes, with facts related to the subject. 6000 w. Inst of Min & Met, Bul 34—July 18, 1907. No. 86495 N.

Boring Devices.

The Valve Mechanisms of Hydraulic Boring Devices (Die Steuerungen der Hydraulischen Tiefbohrrichtungen). Frd. Freise. The first part of the serial deals with devices with spindle valves. Ills. 1600 w. Serial. 1st part. Oest Zeitschr f Berg u Hüttenwesen—July 20, 1907. No. 86248 D.

Cable Ways.

The Cable Ways for Culm of the Courl and Scharnhorst Mines of the Harpener Mining Company (Die Drahtseilbahnen für Versatzmaterial der Zechen Courl und Scharnhorst der Harpener Bergbau-Aktien-Gesellschaft). F. Schulte. Describes a system for transporting culm from these two mines to a central dump. Plan. 2300 w. Glückauf—July 13, 1907. No. 86236 D.

Drills.

The Gordon Drill on the Rand. Information from recent Consular Reports in regard to the operation and trials of this drill. 2000 w. Compressed Air—Aug., 1907. No. 86404.

Haulage.

Rack-rail Haulage in Coal Mines. George E. Lynch. An illustrated article showing how the rack-rail and cog-wheel are used to supplement ordinary traction where steep grades occur in mines. 3000 w. Eng & Min Jour—Aug. 3, 1907. No. 86105.

Hydraulic Mining.

Notes on Hydraulic Mining. Discusses the subject of hydraulic gold mining, with special reference to the Cariboo District, British Columbia, and Yukon Territory. Ills. 4000 w. Mines & Min—Aug., 1907. No. 86093 C.

Joplin District.

Ground Breaking in the Joplin District. Doss Brittain. Illustrated article describing method. Holes are drilled with air drills and squibbed before charging. 2500 w. Eng & Min Jour—Aug. 10, 1907. No. 86334.

Magnetic Surveying.

Magnetic Observations in Geological and Economic Work. Henry Lloyd Smyth. Explains the construction of the dial-compass and the magnetometer, and the fields to which each is adapted. Ills. 4000 w. Ec Geol—June, 1907. Serial. 1st part. No. 86486 D.

Magnetometric Prospecting.

The Locating of Ore by Electricity (Das Aufsuchen von Erzen mittels Elektrizität). Herr Petersson. An explanation of the method of locating and determining the extent of ore bodies used by the Electrical Ore Finding Company, London. Ills. 2500 w. Glückauf—July 20, 1907. No. 86239 D.

Mine Dam.

A Mine Dam to Recover Flooded Workings. John H. Haertter. Plan and description of how difficulties were overcome in constructing a dam to permit unwatering flooded coal-mine workings. 1800 w. Eng & Min Jour—Aug. 17, 1907. No. 86431.

Mine Waters.

Mine Water and Mine Fire in the Neu-Diepenbrock III Mine at Selbeck (Grubenwasser und Grubenbrand in dem Erzbergwerk Neu-Diepenbrock III zu Selbeck). D. Hilt. An exhaustive discussion of the causes of the troubles experienced at this German mine. Ills. 5500 w. Glückauf—July 20, 1907. No. 86238 D.

Ore Handling.

A Cripple Creek Ore-handling Plant. S. A. Worcester. Illustrates and describes a single, counterbalanced skip

We supply copies of these articles. See page 239.

hoist, discharging into self-dumping cars, claiming that it adds 33 per cent. to the capacity of a shaft. 1300 w. Eng & Min Jour—Aug. 24, 1907. No. 86552.

Prospecting.

Practical Points for Prospectors. Matt. W. Alderson. Information from actual experience. 1500 w. Min Wld—Aug. 3, 1907. Serial. 1st part. No. 86113.

Pumping.

Electric Pumping Plant at the Gilly Collieries, Belgium. Dr. Alfred Gradenwitz. Short illustrated description. 1000 w. Prac Engr—Aug. 9, 1907. No. 86452 A.

Quarrying.

Granite Quarrying in Aberdeenshire. William Simpson. An illustrated description of these quarries and the methods of working. 6500 w. Inst of Mech Engrs—July, 1907. No. 86354 N.

Sand Pumping.

Pumping Sand by Compressed Air. Lucius I. Wightman. Illustrated description of a plant at Ottawa, Ill. 1000 w. Compressed Air—Aug., 1907. No. 86403.

Shaft Signals.

Electric Shaft Signals (Die Elektrischen Schachtsignalanlagen). Herr Schmiede. Illustrates and describes various types of bell, methods of installation, etc., giving wiring diagrams. 2000 w. Glückauf—July 6, 1907. No. 86234 D.

Shaft Sinking.

Sinking Through Bad Ground. F. W. Adgate. Describes the sinking of a shaft on the Mesabi range, near Biwabik, Minn. Of interest because of unusual difficulties, and the novel application of the pneumatic process. Ills. 2500 w. Min & Sci Pr—Aug. 10, 1907. No. 86408.

Ventilation of Shafts During Sinking Operations. Gives diagrammatic views and description of an arrangement of "Sirocco" plant for ventilating shafts. 1200 w. Ir & Coal Trds Rev—July 19, 1907. No. 86002 A.

Subsidence.

Subsidence in Underground Mines. Alexander Richardson. A summary of investigations, with suggestions as to means of prevention. 4000 w. Eng & Min Jour—Aug. 3, 1907. No. 86102.

Tin.

Tin Mining in Ulu Selangor, Federated Malay States. E. Nightingale. Describes the geological features and methods of mining. 2000 w. Inst of Min & Met, Bul 34—July 18, 1907. No. 86497 N.

Ventilation.

On the Practical Measurement of Air (Ueber die Praktische Ausführung von Wettermessungen). Kurt Seidl. Illustrates and describes a method of air measurement by anemometer readings at a number of points in a specially-made opening, giving formulæ. 1800 w. Glückauf—July 20, 1907. No. 86241 D.

MISCELLANY.

Bismuth.

Electrolytic Refining of Bismuth. Dr. Arnold Mohn. Describes the process used with Mexican lead-bismuth bullion. 1200 w. Elec-Chem & Met Ind—Aug., 1907. No. 86342 C.

Corundum.

Corundum at Craigmont. H. E. T. Haultain. Describes the deposits of Craig Mountain, the discovery, mining operations; and gives information relating to the applications of corundum. Ills. 3500 w. Can Min Jour—Aug. 1, 1907. No. 86125.

Jamaica.

Geology of Jamaica, as Related to Its History. Rossiter W. Raymond. Outlines the general natural features, indicating briefly their effect upon the history of the island. 2000 w. Min & Sci Pr—Aug. 3, 1907. No. 86188.

Lead.

The Daly-Judge Mine and Mill, Park City, Utah. Paul A. Gow, Andrew M. Howat, George S. Kruger, and F. H. Parsons. A description of the veins, methods of working and timbering, and report of production. Ills. 4000 w. Mines & Min—Aug., 1907. Serial. 1st part. No. 86099 C.

Lead Refining.

The Betts Process at Trail, B. C. A. G. Wolf. Describes the electrolytic refining of lead bullion, treatment of gold and silver slimes, and copper sulphate recovery. Ills. 5000 w. Mines & Min—Aug., 1907. No. 86096 C.

Manganese.

Prospects of Indian Manganese Industry. A. Ghose. Shows that India has attained a leading position in the manganese market, and gives information of interest. 3500 w. Jour Soc of Arts—Aug. 2, 1907. No. 86345 A.

Mercury.

The Use and Care of Mercury. Explains some of the causes of the flouring and sickening of quicksilver, and various methods of remedying the evil. 2500 w. Min & Sci Pr—Aug. 17, 1907. No. 86525.

New Mexico.

Burro Mountains Copper District. William Rogers Wade. Gives briefly the history of the camp and an account of present operations. Ills. 1200 w. Eng & Min Jour—Aug. 24, 1907. No. 86553.

New Zealand.

The Mineral Resources of New Zealand. T. Hilton. Suggestions for the development of the deposits of gold, silver, lead, copper, iron ores, manganese, petroleum, and especially the coal fields.

We supply copies of these articles. See page 239.

6000 w. N Z Mines Rec—May 16, 1907. No. 86153 B.

Nickel Ores.

On the Microstructure of Nickeliferous Pyrrhotites. William Campbell and C. W. Knight. An interesting metallographic study of nickel ores from widely distant localities, with conclusions. Ills. 5000 w. Ec Geol—June, 1907. No. 86485 D.

Ore Deposits.

The Ore Deposits of the Schneeberg near Sterzing in the Tyrol (Ein Beitrag zur Kenntnis der Tektonik der Erzlagerstätten am Schneeberg bei Sterzing in Tyrol). B. Granigg. A contribution to the theory of ore deposits. The first part describes the complex vein system of this Austrian district. Ills. Map. 4000 w. Serial. 1st part. Oest Zeitschr f Berg u Hüttenwesen—July 6, 1907. No. 86247 D.

Tin.

Alluvial Tinstone Deposits of Northern Nigeria. Describes the deposits and the washing and smelting methods used by the natives. 1500 w. Min Jour—Aug. 17, 1907. No. 86597 A.

Electrolytic Refining of Tin. Otto Steiner. Explains the theory and the conditions of importance, describing experiments and methods of working. 4000 w. Elec-Chem & Met Ind—Aug., 1907. No. 86341 C.

RAILWAY ENGINEERING

CONDUCTING TRANSPORTATION.

British Practice.

Note on the Operating of Trains and Locomotives in England (Note sur le Service des Trains et des Machines en Angleterre). MM. Demoulin and Bezier. Illustrates and describes cars and locomotives on British railways and discusses points of difference in British and French operating practice. 12000 w. Rev Gen d Chemins d Fer—July, 1907. No. 86208 G.

Freight Cars.

Freight Car Department. D. T. Taylor. Briefly considers car interchange, inspection, repairs, etc. 3000 w. Pro St Louis Ry Club—July 12, 1907. No. 86005.

Wrecks.

A Disastrous Blast. Map and illustrated account of a blast on May 16, near Lookout Mountain, which wrecked a bridge 600 ft. distant, struck a pile driver 900 ft. distant, killing two men, wrecked a train of 11 freight cars, and did other damage. 500 w. Ry & Engng Rev—Aug. 3, 1907. No. 86119.

Curve Mechanics and the Woodlawn Wreck. T. H. Brigg. A letter from an English writer offering an explanation of the accident in Feb., 1907. 1200 w. R R Gaz—Aug. 23, 1907. No. 86527.

MOTIVE POWER AND EQUIPMENT.

Boiler Tubes.

Causes of Leaks in Locomotive Boiler Tubes. M. E. Wells. Abstract of a paper presented at convention of the Am. Ry. Mas. Mechs.' Assn. Gives a résumé of reported causes and suggested remedies. 1500 w. Eng News—Aug. 29, 1907. No. 86633.

Brakes.

The Braking of Trains at High Speed (Le Freinage des Trains à Grande Vitesse). A. Boyer-Guillon. Outlines the theory of braking, the defects of the common type of air brake and describes the mechanism and advantages of the Maximus brake. Ills. Plate. 4000 w. Génie Civil—July 27, 1907. No. 86214 D.

The Maximus Brake. Illustrated detailed description of an English invention developed in connection with both the vacuum brake and the Westinghouse, which gives a uniform retarding effect. 1600 w. R R Gaz—Aug. 2, 1907. No. 86108.

Brake-Shoes.

Review of the Master Car Builders Brake-Shoe Tests. A report of interesting tests made during the past twelve years at the Purdue University testing plant. 6000 w. St Ry Jour—Aug. 3, 1907. No. 86084.

Car Heating.

Heating and Ventilating of Cars. E. R. Swan. Read before the Am. Soc. of Heat. & Vent. Engrs. Discusses systems that have been tried and gives an illustrated description of the system designed by the writer for the automatic control of the air supply. 6000 w. Heat & Vent Mag—Aug., 1907. No. 86494.

Driving Shoes.

Driving Shoes and Wedges. Editorial statement of methods of repair. 1200 w. Ry & Loc Engng—Aug., 1907. No. 86047 C.

Driving Springs.

Tests of the Live Load on Driving Springs. Charles A. Howard. Illustrates and describes apparatus designed for the purpose of furnishing data to enable the live load to be determined. 1500 w. Ry Age—Aug. 2, 1907. No. 86122.

Dynamometer Car.

100,000 Lb. Capacity Dynamometer Car.

We supply copies of these articles. See page 239.

Illustrated detailed description of a recently completed car for the Pennsylvania Railroad. 4000 w. Am Engr & R R Jour—Aug., 1907. No. 86048 C.

Fire-Boxes.

On Repairing the Tube Plates of Locomotive Fire-Boxes. S. Ragno. On the advantage of such repairs, and the methods used. Ills. 6700 w. Bul Int Ry Cong —July, 1907. No. 86493 E.

Freight Cars.

Forty-Ton Well Wagon. Illustrated description of a special car for carrying heavy loads of awkward size, in use on the Great Northern Railway of England. 600 w. Ry & Loc Engng—Aug., 1907. No. 86045 C.

Special Service Wagons; Great Central Railway Company. Illustrates and describes types of cars used on this English railway for carrying special forms of goods which are too bulky or awkward in shape, or too heavy for the usual cars. 1200 w. Plate. Engng—Aug. 9, 1907. No. 86469 A.

Steel, Triple Hopper-Bottom, Self-Clearing Coke Car. Gives illustration, plan, elevation, and sections of new cars for the Pittsburg & Lake Erie R. R. 800 w. Am Engr & R R Jour—Aug., 1907. No. 86050 C.

Locomotives.

A Balanced Compound Locomotive for the Italian State Railroads. Illustrated description of an express locomotive having novel features of exceptional interest 2500 w. R R Gaz—Aug. 2, 1907. No. 86110.

A New Mountain Locomotive. Trans. from *La Nature*. An improved system with increased adherence, used on the Puy de Dome road in France, is illustrated and described. 1800 w. Sci Am Sup —Aug. 3, 1907. No. 86069.

An Interesting Locomotive Conversion. Illustrates and describes the rebuilding of some locomotives on the Great Western Ry., changing 6-wheel engines with tenders into tank locomotives with the 2-6-2 wheel arrangement. 1000 w. Mech Engr —Aug. 3, 1907. No. 86351 A.

Atlantic Locomotives of the Austrian State Railways and the Southern Railway (Atlantik-Lokomotive der Oesterreichischen Staatsbahnen und der Südbahn). R. Sanzin. Illustrated detailed description with dimensions and results of tests. 3000 w. Serial. 2 parts. Verkehrstech Woche u Eisenbahntech Zeitschr—July 6 and 13, 1907. No. 86242 each D.

Bothwell Convertible Locomotive. Illustrates and describes a reconstructed locomotive aiming at maximum hauling capacity with the least weight. 700 w. Ry & Engng Rev—Aug. 3, 1907. No. 86118.

British-Built Locomotives for India. Illustrations, with descriptions of a new 4-6-0 type express engine for the Bombay, Baroda, and Central India Ry., and a duplex, or Fairlie type locomotive for the Burma Ry. 1500 w. Mech Engr—Aug. 10, 1907. No. 86453 A.

British Tank Locomotives. J. R. Thompson. Illustrated description of a tank locomotive for long-distance service on the Midland Railway of England. 700 w. Cassier's Mag—Aug., 1907. No. 86012 B.

Decapod Locomotive for the Buffalo, Rochester & Pittsburg. Illustrated description of one of the six decapod (2-10-0) locomotives recently built for pusher service. 1200 w. R R Gaz—Aug. 9, 1907. No. 86193.

Locomotives on the Lancashire and Yorkshire Railway. A brief account of the development of the Horwich Works, with illustrated descriptions of engines and motor cars built. 1300 w. Engng—Aug. 9, 1907. No. 86470 A.

Mallet Compound Locomotive for the Erie Railroad. Compares the Erie engine with the Baltimore & Ohio engines, and gives illustrated description of interesting features, and the principal dimensions. 2200 w. R R Gaz—Aug. 16, 1907. No. 86414.

Pacific Locomotive for the Pennsylvania Lines. The heaviest engine of this type ever constructed, having a total weight of 269,200 pounds, is illustrated and described. 500 w. Ry Age—Aug. 23, 1907. No. 86566.

Prairie for the Soo Lines. Illustration, with brief description of engines intended for mixed service. 700 w. Ry & Loc Engng—Aug., 1907. No. 86044 C.

Prairie Locomotive for the Minneapolis, St. Paul Sault Ste. Marie. Illustration, dimensions and particulars of engines for both freight and passenger service. 700 w. R R Gaz—Aug. 2, 1907. No. 86107.

Recent British Locomotives for Abroad. Illustrated description of a 4-cylinder balanced compound locomotive for the Buenos Ayres Gt. Southern Ry., and of a 6-wheeled locomotive crane engine for India. 700 w. Mech Engr—July 27, 1907. No. 86156 A.

Siamese and Westphalians. Illustrates two standard gauge engines built in Germany. One is a freight engine for burning wood; the other of unusually strong construction and special design to meet requirements of the Westphalia Ry. 400 w. Ry & Loc Engng—Aug., 1907. No. 86046 C.

Simple Consolidation Locomotive. Illustrated description of a very interesting locomotive, fitted with Baldwin superheater, being shown at Jamestown Exhi-

We supply copies of these articles. See page 239.

bition. 900 w. Am Engr & R R Jour—Aug., 1907. No. 86049 C.

Six-wheel Coupled Locomotive (Metre-Gauge) for the Federated Malay States Railways. Illustration, with particulars. 500 w. Engng—July 26, 1907. No. 86176 A.

Ten Wheeled Coupled Freight Locomotives for the Austrian State Railways (5-5 Gekuppelte Güterzugslokomotive der Oesterr. Staatsbahnen). R. Sanzin. Illustrated detailed description. 3000 w. Oest Wochenschr f d Oeffent Baudienst—July 20, 1907. No. 86269 D.

Ten-Wheel Locomotive for the Canadian Pacific. Engines equipped with the Horsey-Vaughan type of superheater, and representing the use of large cylinders and low boiler pressure in conjunction with superheated steam are illustrated and described. 500 w. Ry Age—Aug. 23, 1907. No. 86568.

The Work of the "Experiments" on the London and Northwestern Railway. On the performance of the first-six-coupled express passenger engines tried on this line, giving records of the work on the southern section, between Euston and Crewe. 2500 w. Engng—July 26, 1907. No. 86174 A.

Motor Cars.

New Steam Motor Cars Designed by F. X. Komeret, Vienna (Neuere Dampfwagen von F. X. Komaret in Wien). C. Guillery. Illustrated detailed description of boiler, engine and car, and the result of competitive tests. 4000 w. Glasers Ann —July 15, 1907. No. 86258 D.

Narrow-Gauge.

The Longest Narrow-Gauge Light Railway in the World. An illustrated detailed description of the Otavi Railway, in German South-West Africa, and its rolling-stock. 2500 w. Engng—July 19, 1907. No. 85991 A.

Overbalancing.

The Overbalancing of Locomotives with Regard to the Dampening Effect of Springs (Das Wogen und Nicken der Lokomotive unter Berücksichtigung der Dämpfenden Wirkung der Federn). W. Lindemann. A mathematical paper. Ills. 3500 w. Glasers Ann—July 1, 1907. No. 86257 D.

Resistance.

The Resistance of Railway Trains. Editorial review of investigations made to determine train resistance. 2000 w. Engng —July 26, 1907. No. 86181 A.

Staybolts.

Manganese Bronze Staybolts. M. Rodrigue. Trans. from *Revue Generale des Chemins de Fer.* Report of tests showing that manganese bronze is superior to copper for staybolts used in high-pressure locomotive boilers. 500 w. R R Gaz—Aug. 9, 1907. No. 86194.

Steam Domes.

Wrong Location of Steam Domes. B. H. Jeffries. States the writer's objections to the present location of the dome, and reasons for desiring a change. 800 w. Ry & Engng Rev—Aug. 3, 1907. No. 86120.

"Tiregraph."

A Locomotive Driving-Wheel Recording Device. Illustrates and describes this recording instrument, called a "tiregraph," by means of which the contour of tires is recorded, and reports tests made and conclusions reached. 1200 w. Sci Am—Aug. 17, 1907. No. 86417.

Train Lighting.

Train Lighting. H. Henderson. Abstract of a paper read before the Newcastle Local Sec. of the Inst of Elec. Engrs. Deals with the lighting of railway carriages by electricity, giving particulars of cost of equipment and maintenance and describing the various systems. 2500 w. Elect'n, Lond—Aug. 16, 1907. Serial. 1st part. No. 86596 A.

NEW PROJECTS.

India.

Indian Railway Property. Information concerning progress on the different lines and recent important undertakings. 1600 w. Engng—July 26, 1907. No. 86177 A.

N. Y., N. H. & H.

New York, New Haven and Hartford Improvement at New Haven. Explains the general features of the improvements, giving illustrated descriptions of types of bridges and other work of interest. 2000 w. Ry Age—Aug. 9, 1907. No. 86336.

Philippines.

The Railroad Development of the Philippines. P. H. Ashmead. An illustrated account of the progress made in construction, and the industrial effects manifest. 3000 w. Engineering Magazine—Sept., 1907. No. 86607 B.

South America.

The Trans-Andine Railroads. Lewis R. Freeman. An interesting illustrated account of difficult railway building, and of the discovery of a new pass through the Andes so open that a broad gauge line can be run through without building a single tunnel. 2500 w. R R Gaz—Aug. 2, 1907. No. 86109.

PERMANENT WAY AND BUILDINGS.

Improvements.

The Value of Railroad Improvements. Morrell W. Gaines. An examination of money earnings from increased train loads, giving a short résumé of the course of traffic and operating conditions since the early eighties. 4000 w. Engineering Magazine—Sept., 1907. No. 86605 B.

Maintenance of Way.

A Technical and Economic Consideration of Materials for Maintenance of Way

We supply copies of these articles. See page 239.

(Sullo Studio Tecnico ed Economico dei Materiali di Manutenzione dell Massicciate Stradali). 1500 w. Serial. 1st part. Rivista Gen delle Ferrovie—July 28, 1907. No. 86217 D.

Rail Corrugation.

The Origin and Production of Corrugation of Tramway Rails. W. Worby Beaumont. Read before the British Assn. Offers an explanation of the origin and production of these corrugations. 2000 w. Elec Engr, Lond—Aug. 9, 1907. No. 86-456 A.

Rail Laying.

A Machine for Laying Rails in Streets. Illustrated description of the Romapac machine for laying and fixing the rails of street railways. 2500 w. Sci Am Sup—Aug. 24, 1907. No. 86519.

Rails.

Steel Rails of Better Quality. Robert Job. Discusses the need of better rails to meet changed conditions, and considers the latest specifications proposed by the American Society for Testing Materials. 2000 w. Ir Age—Aug. 22, 1907. No. 86500.

Signaling.

Standard Convertible Semaphore Signals of the Belgian State Railways. L. Weissenbruch. Illustrated description of the new semaphores and their use. 7200 w. Bul Int Ry Cong—July, 1907. No. 86492 E.

Simplon.

The Italian Approaches to the Simplon Tunnel. Brief review of the negotiations which made this work possible, illustrating and describing the approaches on the Italian side. 3800 w. Engng—July 26, 1907. Serial. 1st part. No. 86175 A.

Spikes.

Holding Power of Railroad Spikes. Roy I. Webber. From Bul. No. 6 of the Univ. of Ills. Engng. Exp. Station. Report of a series of experiments made to determine the resistance to withdrawal of the same type of spike in different timbers, and of different spikes in the same timber, and whether the preservative has any influence. Ills. 7500 w. R R Gaz—Aug. 9, 1907. No. 86191.

Stations.

The Alterations to Ludgate-Hill Station. Illustrates and describes changes to be made to relieve congested traffic. 700 w. Engr, Lond—Aug. 2, 1907. No. 86-367 A.

The Design of Wayside Stations for Single Lines of Railway. Frederick George Royal-Dawson. Considers types of stations designed for India, especially stations designed for the safety of fast trains, and also the development of local traffic. 8300 w. Inst of Civ Engrs, No. 3671. No. 86371 N.

Terminals.

The Land and Water Terminal of the Seaboard Air Line Railway at Savannah, Ga. Description abstracted from an article by W. Faucette. Plan. 1700 w. Eng News—Aug. 22, 1907. No. 86511.

The Pennsylvania New Terminal, New York. The first of a series of illustrated articles describing in detail the great engineering work in progress to furnish a station in New York City to serve the Pennsylvania Lines. 2500 w. Engr, Lond—July 19, 1907. Serial. 1st part. No. 86000 A.

Track Elevation.

Track Elevation on the Milwaukee Division, Chicago & Northwestern Railway. Brief illustrated description of the work. 1000 w. Ry Age—Aug. 16, 1907. No. 86437.

Tracks.

Notes on English Railway Track. Gives opinions based on a recent examination of railways in England and America. 1800 w. Eng News—Aug. 8, 1907. No. 86310.

Turntables.

Standard Turntable Pit: Seaboard Air Line Ry. Philip Aylett. Drawings and description of a pit consisting essentially of a concrete circular wall, in the foundation of which is embedded and bolted the circular rail. 700 w. Eng News—Aug. 15, 1907. No. 86392.

TRAFFIC.

Freight.

Loss and Damage to Freight. An address by Robert L. Calkins before the N. Y. Traffic Club. Discusses some of the causes of losses and delays and the payment of claims, urging the closer relationship and co-operation between different interests. 1200 w. R R Gaz—Aug. 9, 1907. No. 86192.

Preference Freight. An interesting account of the manner of handling this class of freight. 2500 w. Ry & Engng Rev—Aug. 10, 1907. No. 86337.

MISCELLANY.

Abandoned Railway.

A Derelict Somersetshire Railway. An illustrated account of a mineral railway abandoned because of the decay of the industry it was built to serve. 1800 w. Engr, Lond—Aug. 9, 1907. No. 86476 A.

Construction Organization.

See Industrial Economy.

Government Control.

Secretary Taft's Columbus Speech. Extract concerning railroads and their regulation, with editorial comment. 4200 w. R. R. Gaz—Aug. 23, 1907. No. 86528.

Government Ownership.

The Costly Mistake of State Railroads. Information given before the Viceregal Commission on Irish Railways is commented upon editorially, with review of

E. A. Pratt's book on State Railways, especially in Belgium. 2000 w. R R Gaz —Aug. 9, 1907. No. 86190.

Japan.

The Development of Japanese Transportation Facilities (Die Entwicklung des Japanischen Verkehrswesens). Dr. Wolff. Describes the progress in extension of railway and steamship lines and gives tables showing the development of commerce and traffic during the past twenty years. 4000 w. Verkehrstech Woche u Eisenbahntech Zeitschr—July 27, 1907. No. 86245 D.

Legislation.

Clashes Between Federal and State Authority. Editorial on the recent legislation in the Southern States in regard to railroad rates. 2000 w. R R Gaz—Aug. 23, 1907. No. 86526.

Railroad Legislation in Connecticut. Clarence Deming. A review of the steam and trolley legislation of the session just ended. 1600 w. R R Gaz—Aug. 9, 1907. No. 86195.

Mexico.

Mexican Government Railroad High Finance. A review of railroad development and the approaching consolidation into one great system under the control of the national government. 2000 w. R R Gaz—July 19, 1907. No. 85779.

The Railroads of Mexico. Erdis G. Robinson. Reviews their development. The present number describes the resources and topography of the country. 1800 w. R R Gaz—July 12, 1907. Serial. 1st part. No. 85515.

New Haven Merger.

The New Haven-Boston & Maine System. Gives two maps showing the steam railroad mileage owned by the N. Y., N. H. & H. R. R. and the B. & M. R. R., with remarks on the consolidation. Also editorial. 2000 w. R R Gaz—Aug. 23, 1907. No. 86529.

Reading.

Early Years of the Philadelphia & Reading. C. H. Caruthers. A review of the early history of this line, illustrating and describing early engines used, and other peculiarities of equipment. 7000 w R R Gaz—July 26, 1907. No. 85904.

U. S. Railroads.

Agitation Against the Railroads. Col. H. G. Prout. An address delivered before the Traffic Club of Pittsburg, on the present attitude of the public toward the railroads. 4000 w. Ry Age—July 12, 1907. No. 85555.

STREET AND ELECTRIC RAILWAYS

Atlantic Shore Line.

The Atlantic Shore Line Railway. Illustrates and describes a recently completed new link between York Beach and Kennebunk, connecting the east and west branches of this system, which has a length of about 100 miles. 3500 w. Elec Ry Rev—Aug. 24, 1907. No. 86565.

Cars.

A Radical Design of Semi-Steel Car. Illustrated description of cars for service on interurban systems near Milwaukee. 1200 w. St Ry Jour—Aug. 10, 1907. No. 86320.

Electrification.

Electrification of the New York, New Haven & Hartford. E. H. McHenry. A fully illustrated article describing important features of the system. Also short editorial. 9500 w. R R Gaz—Aug. 16, 1907. No. 86415.

Great Western Railway.—Electric Power and Lighting and the Electrification of the Hammersmith & City Railway. Illustrated detailed description of the new electric supply system that has been installed in London. 4500 w. Elect'n, Lond —Aug. 2, 1907. Serial. 1st part. No. 86361 A.

Great Western Railway. Illustrated detailed description of the new electric power and lighting system, and the electrification of the Hammersmith and City Railway. 15000 w. Tram & Ry Wld—Aug. 1, 1907. No. 86455 B.

Heavy Electric Traction on the New York, New Haven & Hartford Railroad. E. H. McHenry. Explains the reasons for the adoption of the 25-cycle, 11,000-volt system, and the expected results, giving an illustrated detailed description of the system. 7000 w. St Ry Jour—Aug. 17, 1907. Serial. 1st part. No. 86443.

Some Facts and Problems Bearing on Electric Trunk-Line Operation. Frank J. Sprague. Analyzes some phases of problems discussed by engineers, giving comparative facts, and developments in electric locomotive construction, and features of the equipments now commanding attention. Ills. 23000 w. Pro Am Inst of Elec Engrs—July, 1907. No. 86538 D.

The Electrification of the Hammersmith & City Railway Branch of the Great Western Railway. Illustrated detailed description of this recently completed electric traction system in London. 6500 w. St Ry Jour—Aug. 3, 1907. No. 86083.

We supply copies of these articles. See page 239.

The Inauguration of the New Haven Railroad Electric Service. An illustrated description of the first application in the United States of single phase traction to an important trunk railroad. The Cos Cob power station, the overhead trolley system, and the electric locomotives are described. 1500 w. Sci Am—Aug. 3, 1907. No. 86064.

Feeders.

Determining the Size of Feeders. Henry Docker Jackson. Briefly explains methods of calculating used. 1200 w. Elec Ry Rev—Aug. 17, 1907. No. 86442.

Frequency.

The Choice of Frequency for Single-Phase Alternating-Current Railway Motors. A. H. Armstrong. Aims to open a discussion on the relative merits of 25-cycles and a lower frequency, briefly considering the advantages and disadvantages of the present, and of any proposed standard. 1700 w. Pro Am Inst of Elec Engrs—July, 1907. No. 86532 D.

Twenty-five versus Fifteen Cycles for Heavy Railways. N. W. Storer. Presents arguments in favor of each, discussing them in detail. 3500 w. Pro Am Inst of Elec Engrs—July, 1907. No. 86533 D.

Grade Reduction.

Lowering the Grade of a Tunnel at Kansas City, Mo. Abstract of a paper by W. M. Archibald on the reconstruction of the 8th Street tunnel of the Metropolitan St. Ry., at Kansas City, Mo. Ills. 1500 w. Eng News—Aug. 1, 1907. No. 86081.

History.

The Historical Development of Electric Railways From Their Introduction to the Present (Die Geschichtliche Entwicklung der Elektrischen Bahnen vom Ursprung bis zur Neuzeit). Herr Peter. Traces the development of electric traction from W. von Siemen's line established in Berlin in 1879, giving a chronological table of leading events. 5000 w. Glasers Ann—July 1, 1907. No. 86256 D.

Interurban.

Interurban Railway Development Near Milwaukee. Map and illustrated description of the large interconnected system planned, and some of the construction work. 3500 w. St Ry Jour—Aug. 3, 1907. No. 86082.

Italy.

Italian Tramways (Die Straszenbahnen Italiens). D. Liebmann. Discusses the extent and distribution of electric railways in Italy, with general notes on Italian practice. 2000 w. Verkehrstech Woche u Eisenbahntech Zeitschr—July 6, 1907. No. 86243 D.

The Single-Phase Electric Railroad of the Val Brembana (Ferrovia Elettrica Monofase della Val Brembana). Illustrated description of the electric locomotive built by the Westinghouse Company. 2200 w. Industria—July 14, 1907. No. 86220 D.

Locomotive.

Single-Phase 20,000-Volt Locomotive for Swedish State Railways. Dr. Alfred Gradenwitz. Illustration with description of the normal-gauge locomotive under trial. 700 w. Prac Engr—Aug. 9, 1907. No. 86451 A.

Paris.

The Construction of the New Lines of the Paris City Railways (Ueber die Bauten der Neuen Linien der Pariser Stadtbahn). E. A. Ziffer. Describes recent extensions to the Paris tramway system, tunnels, stations, etc., giving costs. 5000 w. Mitt d Ver f d Förd d Lokal u Strazenbahnwesens—July, 1907. No. 86222 F.

Power Station.

The Reconstruction of the East St. Louis & Suburban Ry. Power Station. Illustrates and describes additions and rearrangement. 2500 w. Eng Rec—Aug. 3, 1907. No. 86089.

Shops.

New Shops of the Bangor Railway. Illustrated description of shops built of concrete blocks, and of their arrangement and methods. 1800 w. Elec Ry Rev—Aug. 10, 1907. No. 86322.

Single-Phase.

Single-Phase vs. Direct-Current Railway Operation. Malcolm MacLaren. Discusses features of the single-phase system which the writer feels have been inadequately presented, giving comparisons. 2500 w. Elec Jour—Aug., 1907. No. 86400.

Single-Phase versus Three-Phase Generation for Single-Phase Railways. A. H. Armstrong. Various methods of distribution are given with some of the advantages and disadvantages of each. 1300 w. Pro Am Inst of Elec Engrs—July, 1907. No. 86531 D.

The Pittsburg & Butler Street Railway Co. M. N. Blakemore. Illustrated description of an interurban single-phase electric railway and its equipment. 3300 w. St Ry Jour—Aug. 10, 1907. Serial. 1st part. No. 86319.

Standardization.

Meeting of the Standardization Committee. An account of the meeting of the Committee of Standards of the Am. St. & Int. Ry. Engng Assn., giving a summary of the discussions. 3000 w. St Ry Jour—Aug. 10, 1907. No. 86321.

Tracks.

Wear and Maintenance of Street Railway Track. C. F. Wike. Abstract of a paper read before the Munic. & Co. Engrs. at Liverpool, Eng. Concerning the cost of repairs and renewals at Sheffield, Eng. 1700 w. Eng News—Aug. 29, 1907. No. 86635.

We supply copies of these articles. See page 239.

EXPLANATORY NOTE– THE ENGINEERING INDEX.

We hold ourselves ready to supply—usually by return of post—the full text of every article indexed in the preceding pages, *in the original language*, together with all accompanying illustrations; and our charge in each case is regulated by the cost of a single copy of the journal in which the article is published. The price of each article is indicated by the letter following the number. When no letter appears, the price of the article is 20 cts. The letter A, B, or C denotes a price of 40 cts.; D, of 60 cts.; E, of 80 cts.; F, of $1.00; G, of $1.20; H, of $1.60. When the letter N is used it indicates that copies are not readily attainable, and that particulars as to price will be supplied on application. Certain journals, however, make large extra charges for back numbers. In such cases we may have to increase proportionately the normal charge given in the Index. In ordering, care should be taken to *give the number* of the article desired, not the title alone.

Serial publications are indexed on the appearance of the first installment.

SPECIAL NOTICE.—To avoid the inconvenience of letter-writing and small remittances, especially from foreign countries, and to cheapen the cost of articles to those who order frequently, we sell coupons at the following prices:—20 cts. each or twelve for $2.00, thirty-three for $5, and one hundred for $15.

Each coupon will be received by us in payment for any 20-cent article catalogued in the Index. For articles of a higher price, one of these coupons will be received for each 20 cents; thus, a 40-cent article will require two coupons; a 60-cent article, three coupons; and so on. The use of these coupons is strongly commended to our readers. They not only reduce the cost of articles 25 per cent. (from 20c. to 15c.), but they need only a trial to demonstrate their very great convenience—especially to engineers in foreign countries, or away from libraries and technical club facilities.

Write for a sample coupon—free to any part of the world.

CARD INDEX.—These pages are issued separately from the Magazine, printed on one side of the paper only, and in this form they meet the exact requirements of those who desire to clip the items for card-index purposes. Thus printed they are supplied to regular subscribers of THE ENGINEERING MAGAZINE at 10 cents per month, or $1.00 a year; to non-subscribers, 25 cts. per month, or $3.00 a year.

THE PUBLICATIONS REGULARLY REVIEWED AND INDEXED.

The titles and addresses of the journals regularly reviewed are given here in full, but only abbreviated titles are used in the Index. In the list below, *w* indicates a weekly publication, *b-w*, a bi-weekly, *s-w*, a semi-weekly, *m*, a monthly, *b-m*, a bi-monthly, *t-m*, a tri-monthly, *qr*, a quarterly, *s-q*, semi-quarterly, etc. Other abbreviations used in the index are: Ill—Illustrated: W—Words; Anon—Anonymous.

Alliance Industrielle. *m.* Brussels.
American Architect. *w.* New York.
Am. Engineer and R. R. Journal. *m.* New York.
American Jl. of Science. *m.* New Haven, U. S. A.
American Machinist. *w.* New York.
Annales des Ponts et Chaussées. *m.* Paris.
Ann. d Soc. Ing. e d Arch. Ital. *w.* Rome.
Architect. *w.* London.
Architectural Record. *m.* New York.
Architectural Review. *s-q.* Boston.
Architect's and Builder's Magazine. *m.* New York.
Australian Mining Standard. *w.* Melbourne.
Autocar. *w.* Coventry, England.
Automobile. *w.* New York.
Automotor Journal. *w.* London.
Beton und Eisen. *qr.* Vienna.
Boiler Maker. *m.* New York.
Brass World. *m.* Bridgeport, Conn.
Brit. Columbia Mining Rec. *m.* Victoria, B. C.
Builder. *w.* London.
Bull. Am. Iron and Steel Asso. *w.* Phila., U. S. A.
Bulletin de la Société d'Encouragement. *m.* Paris.
Bulletin of Dept. of Labor. *b-m.* Washington.
Bull. Soc. Int. d'Electriciens. *m.* Paris.
Bulletin of the Univ. of Wis., Madison, U. S. A.
Bulletin Univ. of Kansas. *b-m.* Lawrence.
Bull. Int. Railway Congress. *m.* Brussels.
California Jour. of Tech. *m.* Berkeley, Cal.
Canadian Architect. *m.* Toronto.
Canadian Electrical News. *m.* Toronto.
Canadian Engineer. *m.* Toronto and Montreal.
Canadian Mining Journal. *b-w.* Toronto.
Cassier's Magazine. *m.* New York and London.
Cement. *b-m.* New York.
Cement Age. *m.* New York.
Central Station. *m.* New York.
Chem. Met. Soc. of S. Africa. *m.* Johannesburg.
Colliery Guardian. *w.* London.
Compressed Air. *m.* New York.
Comptes Rendus de l'Acad. des Sciences. *w.* Paris.
Consular Reports. *m.* Washington.
Deutsche Bauzeitung. *b-w.* Berlin.

Domestic Engineering. *w.* Chicago.
Economic Geology. *m.* So. Bethlehem, Pa.
Electrical Age. *m.* New York.
Electrical Engineer. *w.* London.
Electrical Review. *m.* London.
Electrical Review. *w.* New York.
Electric Journal. *m.* Pittsburg, Pa.
Electric Railway Review. *w.* Chicago.
Electrical World. *w.* New York.
Electrician. *w.* London.
Electricien. *w.* Paris.
Electrochemical and Met. Industry. *m.* N. Y.
Elektrochemische Zeitschrift. *m.* Berlin.
Elektrotechnik u Maschinenbau. *w.* Vienna.
Elektrotechnische Rundschau. *w.* Potsdam.
Elektrotechnische Zeitschrift. *w.* Berlin.
Elettricità. *w.* Milan.
Engineer. *w.* London.
Engineer. *s-m.* Chicago.
Engineering. *w.* London.
Engineering-Contracting. *w.* New York.
Engineering Magazine. *m.* New York and London.
Engineering and Mining Journal. *w.* New York.
Engineering News. *w.* New York.
Engineering Record. *w.* New York.
Eng. Soc. of Western Penna. *m.* Pittsburg, U. S. A.
Far Eastern Review. *m.* Manila, P. I.
Fire and Water. *w.* New York.
Foundry. *m.* Cleveland, U. S. A.
Génie Civil. *w.* Paris.
Gesundheits-Ingenieur. *s-m.* München.
Giorn. dei Lav. Pubb. e d Str. Ferr. *w.* Rome.
Glaser's Ann. f Gewerbe & Bauwesen. *s-m.* Berlin.
Heating and Ventilating Mag. *m.* New York.
Ice and Refrigeration. *m.* New York.
Industrial World. *w.* Pittsburg.
Ingenieria. *b-m.* Buenos Ayres.
Ingenieur. *w.* Hague.
Insurance Engineering. *m.* New York.
Int. Marine Engineering. *m.* New York.
Iron Age. *w.* New York.
Iron and Coal Trades Review. *w.* London.
Iron and Steel Trades Journal *w.* London.
Iron Trade Review. *w.* Cleveland, U. S. A.
Jour. of Accountancy. *m.* N. Y.
Journal Asso. Eng. Societies. *m.* Philadelphia.
Journal of Electricity. *m.* San Francisco.
Journal Franklin Institute. *m.* Philadelphia.
Journal Royal Inst. of Brit. Arch. *s-qr.* London.
Jour. Roy. United Service Inst. *m.* London.
Journal of Sanitary Institute. *qr.* London.
Jour. of South African Assn. of Engineers. *m.* Johannesburg, S. A.
Journal of the Society of Arts. *w.* London.
Jour. Transvaal Inst. of Mech. Engrs., Johannesburg, S. A.
Jour. of U. S. Artillery. *b-m.* Fort Monroe, U. S. A.
Jour. W. of Scot. Iron & Steel Inst. *m.* Glasgow.
Journal Western Soc. of Eng. *b-m.* Chicago.
Journal of Worcester Poly. Inst., Worcester, U. S. A.
Locomotive. *m.* Hartford, U. S. A.
Machinery. *m.* New York.
Madrid Cientifico. *t-m.* Madrid.
Manufacturer's Record. *w.* Baltimore.
Marine Review. *w.* Cleveland, U. S. A.
Men. de la Soc. des Ing. Civils de France. *m.* Paris.
Métallurgie. *w.* Paris.
Minero Mexicano. *w.* City of Mexico.
Mines and Minerals. *m.* Scranton, U. S. A.
Mining and Sci. Press. *w.* San Francisco.
Mining Journal. *w.* London.
Mining Reporter. *w.* Denver, U. S. A.
Mittheilungen des Vereines für die Förderung des Local und Strassenbahnwesens. *m.* Vienna.
Motor Wagon. *w.* Cleveland, U. S. A.
Municipal Engineering. *m.* Indianapolis, U. S. A.
Municipal Journal and Engineer. *w.* New York.
Nature. *w.* London.
Nautical Gazette. *w.* New York.
New Zealand Mines Record. *m.* Wellington.
Oest. Wochenschr. f. d. Oeff. Baudienst. *w.* Vienna.
Oest. Zeitschr. Berg & Hüttenwesen. *w.* Vienna.
Plumber and Decorator. *m.* London.
Popular Science Monthly. *m.* New York.
Power. *m.* New York.
Practical Engineer. *w.* London.
Pro. Am. Soc. Civil Engineers. *m.* New York.
Pro. Canadian Soc. Civ. Engrs. *m.* Montreal.
Proceedings Engineers' Club. *qr.* Philadelphia.
Pro. St. Louis R'way Club. *m.* St. Louis, U. S. A.
Pro. U. S. Naval Inst. *qr.* Annapolis, Md.
Quarry *m.* London.
Queensland Gov. Mining Jour. *m.* Brisbane, Australia.
Railroad Gazette. *w.* New York.
Railway Age. *w.* Chicago.
Railway & Engineering Review. *w.* Chicago.
Railway and Loc. Engng. *m.* New York.
Railway Master Mechanic. *m.* Chicago.
Revista d Obras. Pub. *w.* Madrid.
Revista Tech. Ind. *m.* Barcelona.
Revue de Mécanique. *m.* Paris.
Revue Gén. des Chemins de Fer. *m.* Paris.
Revue Gén. des Sciences. *w.* Paris.
Revue Industrielle. *w.* Paris.
Revue Technique. *b-m.* Paris.
Rivista Gen. d Ferrovie *w.* Florence.
Rivista Marittima. *m.* Rome.
Schiffbau. *s-m.* Berlin.
Schweizerische Bauzeitung. *w.* Zürich.
Scientific American. *w.* New York.
Scientific Am. Supplement. *w.* New York.
Sibley Jour. of Mech. Eng. *m.* Ithaca, N. Y.
Stahl und Eisen. *s-m.* Düsseldorf.
Stevens Institute Indicator. *qr.* Hoboken, U. S. A.
Street Railway Journal. *w.* New York.
Technograph. *yr.* Urbana, Ill.
Technology Quarterly. *qr.* Boston, U. S. A.
Tijds v h Klijk. Inst. v Ing. *qr.* Hague.
Tramway & Railway World. *m.* London.
Trans. Am. Ins. Electrical Eng. *m.* New York.
Trans. Am. Ins. of Mining Eng. New York.
Trans. Am. Soc. Mech. Engineers. New York.
Trans. Inst. of Engrs. & Shipbuilders in Scotland, Glasgow.
Transport. *w.* London.
Verkehrstechnische Woche und Eisenbahntechnische Zeitschrift. *w.* Berlin.
Wood Craft. *m.* Cleveland, U. S. A.
Yacht. *w.* Paris.
Zeitschr. f. d. Gesamte Turbinenwesen. *w.* Munich.
Zeitschr. d. Mitteleurop. Motorwagon Ver. *s-m.* Berlin.
Zeitschr. d. Oest. Ing. u. Arch. Ver. *w.* Vienna.
Zeitschr. d. Ver. Deutscher Ing. *w.* Berlin.
Zeitschrift für Elektrochemie. *w.* Halle a S.
Zeitschr. f. Werkzeugmaschinen. *b-w.* Berlin.